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JADS JT&E

End-to-End Test Interim Report Phase 2

By: Maj Paul Hovey

February 1999

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Joint Advanced Distributed Simulation
Joint Test Force
2050A 2nd St. SE
Kirtland Air Force Base, New Mexico 87117-5522

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EXECUTIVE SUMMARY

1.0 Introduction

This summary serves as a stand-alone document, as well as part of this report. For that reason, the reader will find some duplication of verbiage and figures between the summary and the full report.

2.0 JADS Overview

The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E) was chartered by the deputy director, Test, Systems Engineering and Evaluation (Test and Evaluation), Office of the Under Secretary of Defense (Acquisition and Technology) in October 1994 to investigate the utility of advanced distributed simulation (ADS) technologies for support of developmental test and evaluation (DT&E) and operational test and evaluation (OT&E). The program is Air Force led with Army and Navy participation. JADS Joint Test Force (JTF) manning currently includes 18 Air Force, 4 Air Force civilians, 12 Army, and 1 Navy civilian. Science Applications International Corporation and the Georgia Tech Research Institute provide contracted technical support. The program is currently scheduled to end in March 2000.

The JADS JTF is directly investigating ADS applications in three slices of the test and evaluation (T&E) spectrum: the System Integration Test (SIT) which explored ADS support of air-to-air missile testing; the End-to-End (ETE) Test which is investigating ADS support for command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) testing; and the Electronic Warfare (EW) Test which is exploring ADS support for EW testing. The JTF is also chartered to observe or participate at a modest level in ADS activities sponsored and conducted by other agencies in an effort to broaden conclusions developed in the three dedicated test areas.

Phase 2, the laboratory test, of the ETE Test is the subject of this summary report.

3.0 ETE Test Overview

The ETE Test is designed to evaluate the utility of ADS to support testing of C4ISR systems. The test uses the Joint Surveillance Target Attack Radar System (Joint STARS) as one component of a representative C4ISR system. The ETE Test also evaluates the capability of the JADS Test Control and Analysis Center (TCAC) to control a distributed test of this type and remotely monitor and analyze test results.

The ETE Test consists of four phases. Phase 1 developed or modified the components needed to develop the ADS test environment. Phase 2 used the ADS test environment to evaluate the utility of ADS to support DT&E and early OT&E of a C4ISR system in a laboratory environment. Phase 3 transitions portions of the architecture to the E-8C aircraft, ensures that the components function properly, and checks that the synthetic environment interacts properly with the aircraft

and actual light ground station module (LGSM). Phase 4 will evaluate the ability to perform test and evaluation of the E-8C and LGSM in a synthetically enhanced live test environment.

4.0 Overview of ETE Test Phase 2

4.1 Purpose

Phase 2 determined the utility of ADS to support DT&E and early OT&E of a C4ISR system in a laboratory environment. Using the components developed in Phase 1, a distributed interactive simulation (DIS) network with appropriate C4ISR and weapon system nodes was developed to evaluate a representative sensor-to-shooter process. A virtual Army Tactical Missile System (ATACMS) battalion (Bn) was used as the engagement system. The test objectives were

JADS Issue 1. What is the present utility of ADS, including DIS, for T&E?

> **JADS Objective 1-1**. Assess the validity of data from tests utilizing ADS, including DIS, during test execution.
>
> **JADS Objective 1-2**. Assess the benefits of using ADS, including DIS, in T&E. This test objective was broken down into subobjectives. (Subobjective 1-2-1 is not applicable to the ETE Test Phase 2.)
>
> > **JADS Subobjective 1-2-2.** Assess ADS capability to support T&E planning and test rehearsal.
> >
> > **JADS Subobjective 1-2-3.** Assess ADS capability to support T&E shortfalls.

JADS Issue 2. What are the critical constraints, concerns, and methodologies when using ADS for T&E?

> **JADS Objective 2-1.** Assess the critical constraints and concerns in ADS performance for T&E. This objective was broken down into subobjectives. (Subobjective 2-1-1 is not applicable to the ETE Test Phase 2.)
>
> > **JADS Subobjective 2-1-2.** Assess network and communications performance constraints and limitations.
> >
> > **JADS Subobjective 2-1-3.** Assess the impact of ADS reliability, availability, and maintainability on T&E.
>
> **JADS Objective 2-2.** Assess the critical constraints and concerns in ADS support systems for T&E. This objective was broken down into subobjectives.

JADS Subobjective 2-2-1. Assess the critical constraints and concerns regarding ADS data management and analysis systems.

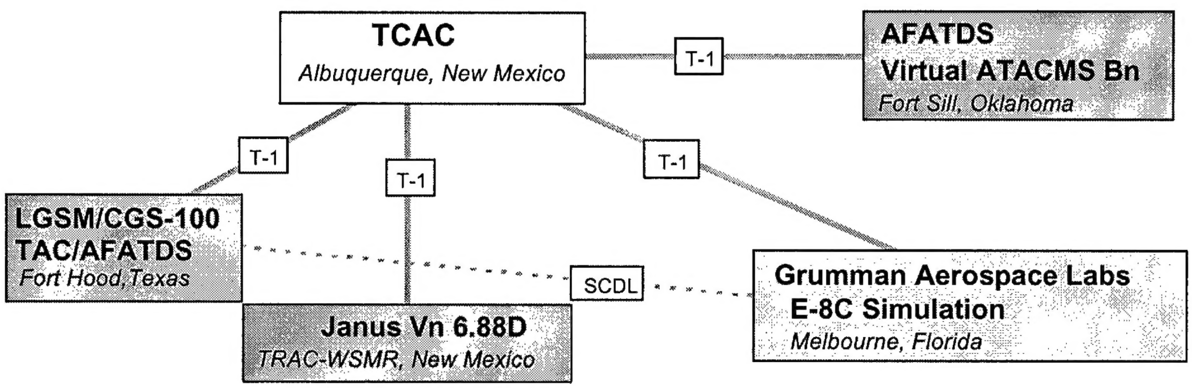
JADS Subobjective 2-2-2. Assess the critical constraints and concerns regarding configuration management of ADS test assets.

JADS Objective 2-3. Develop and assess methodologies associated with ADS for T&E. (Subobjective 2-3-1 is not applicable to the ETE Test Phase 2.)

JADS Subobjective 2-3-2. Develop and assess methodologies associated with test execution and control for tests using ADS.

4.2 Approach

Figure ES-1 provides an overview of the ETE Test synthetic environment.



AFATDS = Advanced Field Artillery Tactical Data System Janus = interactive, computer-based simulation of combat operationsSCDL = surveillance control data link
T-1 = digital carrier used to transmit a formatted digital signal at 1.544 megabits per second
TAC = target analysis cell TRAC - U.S. Army Training and Doctrine Command Analysis Center
WSMR = White Sands Missile Range, New Mexico

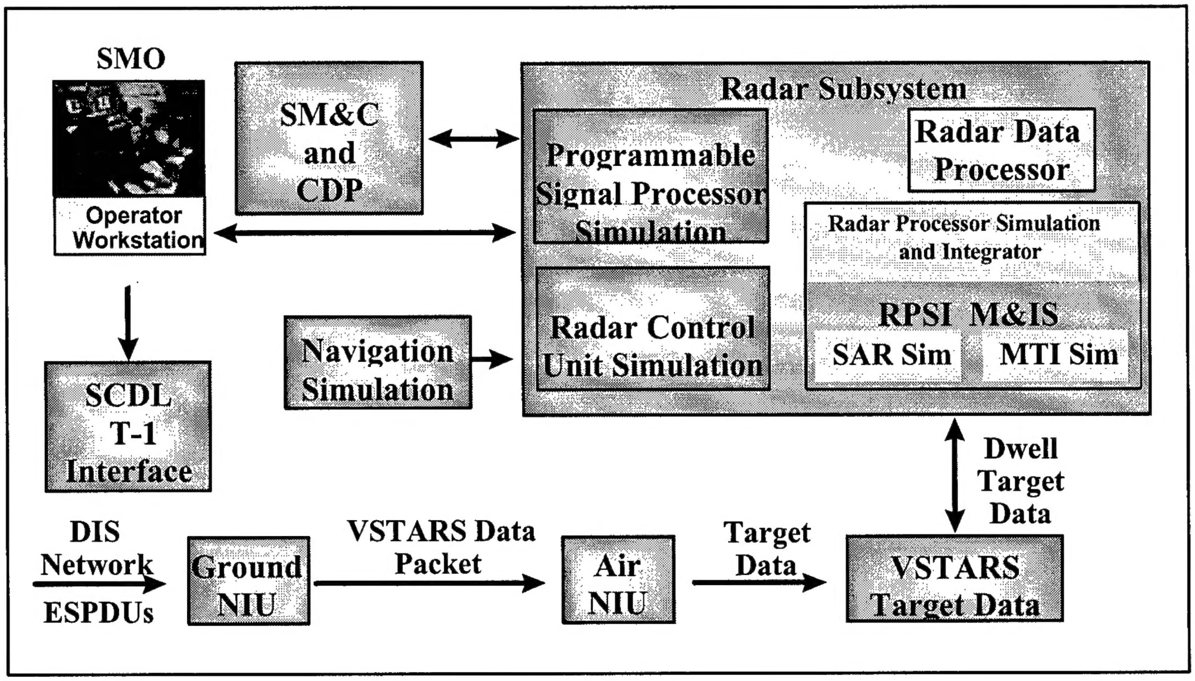
Figure ES-1. ETE Test Phase 2 Synthetic Environment

The ETE Test used the Janus 6.88D simulation to generate the entities representing the elements in the rear of a threat force. The U.S. Army Training and Doctrine Command Analysis Center (TRAC) at White Sands Missile Range (WSMR), New Mexico, provided the Janus scenario feed.

The Test Control and Analysis Center, in Albuquerque, New Mexico, provided test control.

The Joint STARS E-8C simulation, called the Virtual Surveillance Target Attack Radar System (VSTARS), represented the radar subsystem of the Joint STARS E-8C in a laboratory environment. It was composed of a distributed interactive simulation network interface unit (NIU), a radar processor simulator and integrator (RPSI) that contained the two real-time radar simulations with necessary databases, and various simulations of E-8C processes. Figure ES-2

provides more information on the VSTARS architecture. VSTARS was operated at the Northrop Grumman Surveillance and Battle Management Systems facility in Melbourne, Florida.



CDP - central data processor
SM&C - system management and control
T-1 = digital carrier used to transmit a formatted digital signal at 1.544 megabits per second
M&IS - management and integration software
SMO - system management officer

Figure ES-2. VSTARS Architecture

The LGSM and target analysis cell (TAC) were represented by Bravo Company, 303d Military Intelligence Battalion. Fire support, in the form of the Advanced Field Artillery Tactical Data System (AFATDS), was represented by soldiers from the 4th Infantry Division (Mechanized).

Communications among these command, control, communications, computers and intelligence (C4I) systems employed such doctrinally correct means as the CGS-100, a subsystem of the Compartmented All Source Analysis System (ASAS) Message Processing System (CAMPS), remote workstations (RWSs), and AFATDS message traffic.

The Tactical Army Fire Support Model (TAFSM) simulation modeled the Army Tactical Missile System (ATACMS) battalion and sent the fire and detonate protocol data units (PDUs) to the Janus 6.88D simulation. Janus then modeled the engagement results and reflected them in the synthetic environment.

5.0 ETE Test Phase 2 Results

5.1 Schedule

The overall ETE Test schedule is presented in Figure ES-3. Phase 2 testing proceeded as scheduled.

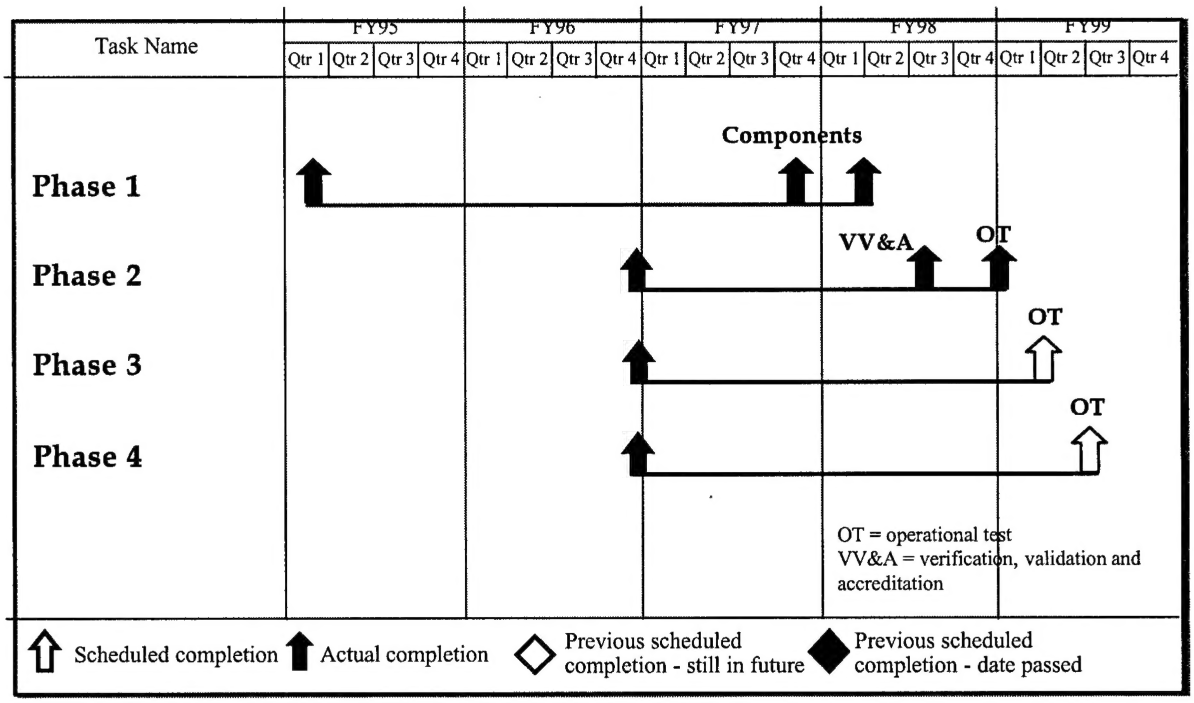


Figure ES-3. ETE Test Schedule

5.2 Fulfillment of Test Objectives

All ETE Test Phase 2 objectives were met. The ETE Test team determined that ADS testing can be beneficial for test planning, rehearsal, and execution, and can result in valid data being collected. During Phase 2, they also identified critical constraints, concerns, and methodologies associated with using ADS for test and evaluation. Finally, the ETE Test team developed and assessed test control and data collection methodologies useful for ADS testing.

6.0 Lessons Learned

6.1 Technical

Testers should carefully plan the development of the simulations and links comprising their ADS environment. During test execution, they must ensure that the time sources are synchronized and continuously monitor PDU traffic. The distributed nature of ADS testing necessitates special equipment for network check-out and verification and requires strict configuration control of analysis tools and collected data.

6.2 Infrastructure and Process

ADS test planning should be detailed enough to encompass key requirements at the earliest possible stages, yet flexible enough to accommodate unexpected situations during test execution. A conservative development approach is recommended -- accomplish risk reduction activities before each ADS test and let each ADS test build on the success of earlier experiments. Successful test execution requires effective internode communication, test and resource control, and data management procedures.

7.0 Conclusions

7.1 Utility

An ADS environment can enhance C4ISR system DT&E and OT&E. In comparison with conventional tests, ADS allows testers to examine C4ISR systems under realistic conditions for longer periods of time, over far larger battlespaces, and at a much lower cost. This versatile technology can provide test environments that include large numbers of entities, entities operating under realistic but unsafe conditions, and joint and combined operations. ADS provides C4ISR system testers with greater flexibility in designing, executing, and analyzing their tests. During DT&E, ADS allows for more realistic compliance testing of C4ISR subsystems and efficient implementation of the test-fix-verify cycle for software development.

ADS testing provides dramatic abilities to test C4ISR systems or components in that system. For instance, in the ETE Test ADS environment, a developmental test could be performed on the Joint STARS operations and control subsystem using VSTARS as a stimulus. With a similar configuration, an operational test could be accomplished on a LGSM. The ETE Test ADS environment also provides ample opportunities to install new components for various types of testing. Links to airborne weapon system simulators, complimentary sensor feeds or other command and control structures can be easily accomplished. The development of an ADS test environment during system development greatly improves opportunities for C4ISR system training after the completion of the test. The same infrastructure developed for testing can be modified and transitioned to a training environment resulting in program savings. This technology allows C4ISR system operators to confirm current tactics, try "what-if" scenarios and new tactics,

test the interoperability and compatibility of their equipment, and gain useful experience in a realistic operating environment containing multiple assets.

7.2 Technical

The Phase 2 test required only a small part of the available bandwidth and exhibited a low PDU latency rate comparable with earlier tests. The ETE Test network was highly reliable during Phase 2 testing due largely to the ETE Test team's extensive pretest risk reduction efforts.

7.3 Infrastructure

Compared to conventional testing, ADS testing reduces the need for large numbers of fielded personnel and vehicles. The ability to automatically collect and analyze test data also reduces the number of people required for setup, execution, and analysis. ADS test success relies on well-organized test control and data management procedures. Distributed testing requires sophisticated instrumentation, trained personnel to operate and maintain that equipment, and funds to support personnel and equipment at distant test nodes.

1.0 Introduction

1.1 Joint Advanced Distributed Simulation Overview

The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E) was chartered by the deputy director, Test, Systems Engineering and Evaluation (Test and Evaluation), Office of the Under Secretary of Defense (OSD) (Acquisition and Technology) in October 1994 to investigate the utility of advanced distributed simulation (ADS) technologies for support of developmental test and evaluation (DT&E) and operational test and evaluation (OT&E). The program is Air Force led with Army and Navy participation. JADS Joint Test Force (JTF) manning currently includes 18 Air Force military, 4 Air Force civilians, 12 Army, and 1 Navy civilian. Science Applications International Corporation and the Georgia Tech Research Institute provide contracted technical support. The program is currently scheduled to end in March 2000.

The JADS JT&E charter focuses on three issues: what is the present utility of ADS, including distributed interactive simulation (DIS), for test and evaluation (T&E); what are the critical constraints, concerns, and methodologies when using ADS for T&E; and what are the requirements that must be introduced into ADS systems if they are to support a more complete T&E capability in the future. From these issues, objectives and measures have been developed to guide the evaluation.

The JADS JTF is directly investigating ADS applications in three slices of the T&E spectrum: the System Integration Test (SIT) which explores ADS support of air-to-air missile testing; the End-to-End (ETE) Test which investigates ADS support for command, control, communications, computers, and intelligence, surveillance and reconnaissance (C4ISR) testing; and the Electronic Warfare (EW) Test which explores ADS support for EW testing. Each test will apply the JADS objectives and measures as appropriate to conduct their evaluation. The JTF is also chartered to observe or participate at a modest level in ADS activities sponsored and conducted by other agencies in an effort to broaden conclusions developed in the three dedicated test areas.

The JADS ETE Test is the subject of this report and is described in the next section; the following is a brief synopsis of the SIT and EW Test.

The SIT evaluated the utility of using ADS to support cost-effective testing of an integrated missile weapon/launch aircraft system in an operationally realistic scenario. The SIT also evaluated the capability of the JADS Test Control and Analysis Center (TCAC) to control a distributed test of this type and to remotely monitor and analyze test results. The SIT consisted of two phases each of which culminated in three flight missions. The missions simulated a single shooter aircraft launching an air-to-air missile against a single target aircraft. In the Linked Simulators Phase (LSP), the shooter, target, and missile were all represented by simulators. In the Live Fly Phase (LFP), the shooter and target were represented by live aircraft and the missile by a simulator.

The EW Test will evaluate the utility of ADS in a distributed EW environment. The first phase was open air testing to develop a performance baseline for two subsequent test phases. The first distributed test phase employed a linked architecture using Department of Defense's (DoD) high level architecture (HLA) which included a digital simulation model of the ALQ-131 self-protection jammer, threat simulation facilities, and constructive models which support replication of the open air environment. In the second phase, an installed systems test facility was substituted for the digital model. In both distributed test architectures, system performance data will be compared with live fly data for verification and validation (V&V).

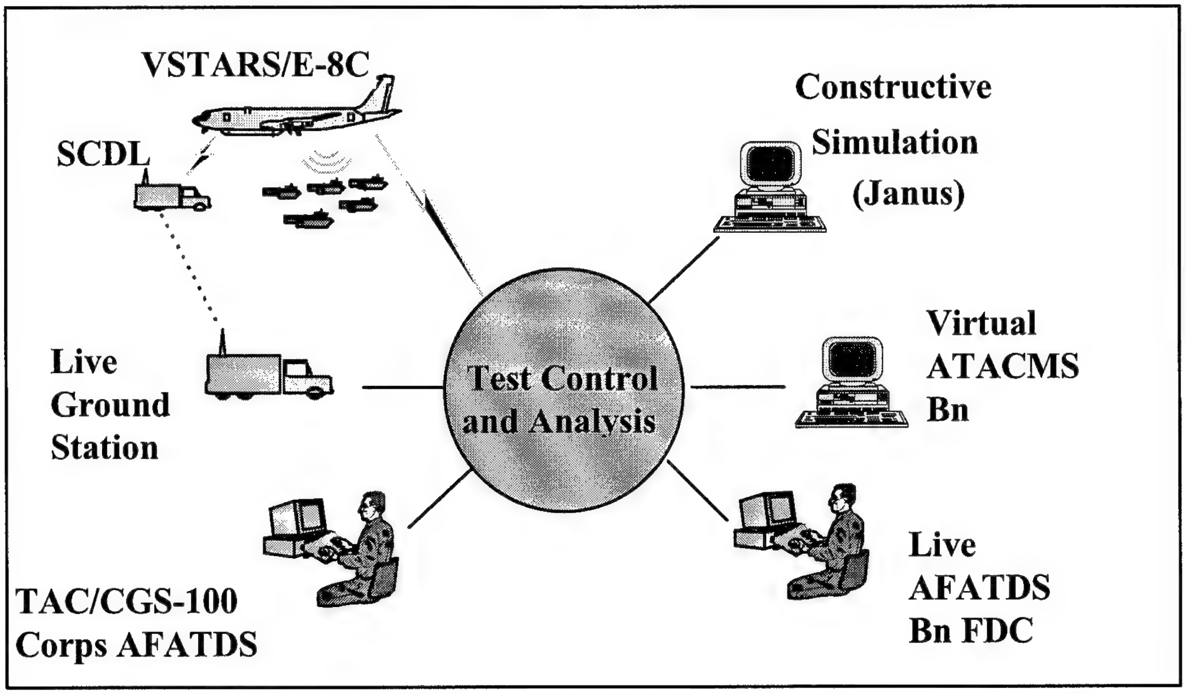
1.2 Test Overview

The ETE Test is designed to evaluate the utility of ADS to support testing of C4ISR systems. It will conduct its T&E utility evaluation in an ADS-enhanced test environment, using the Joint Surveillance Target Attack Radar System (Joint STARS) as one component of a representative C4ISR environment. The ETE Test will also evaluate the capability of the JADS TCAC to control a distributed test of this type and to remotely monitor and analyze test results

The ETE Test is using distributed simulation to assemble an enhanced environment for testing C4ISR systems. The intent is to provide a complete, robust set of interfaces from sensor to weapon system, including the additional intermediate nodes that would be found in a tactical engagement. The test will trace a thread of the complete battlefield process from target detection to target assignment and engagement at corps level using ADS. It will allow the tester to evaluate the thread as a whole or the contribution of any of the parts individually and to evaluate what effects an operationally realistic environment has on the system under test.

The ETE Test is designed to add additional entities in a seamless manner to the battlefield seen by Joint STARS. In addition, adding some of the complementary suite of other command, control, communications, computers and intelligence (C4I) and weapon systems with which Joint STARS would interact will enable the test team to evaluate the utility of an ADS-enhanced test environment.

The test concept (Figure 1) is to use ADS to supplement the operational environment experienced by the E-8C and light ground station module (LGSM) operators. By mixing available live targets with targets generated by a constructive model, a battle array approximating the major systems present in a notional corps area of interest can be presented. By constructing a network with nodes representing appropriate C4I and weapon systems, a more robust cross section of players is available for interaction with the E-8C and LGSM operators.



AFATDS = Advanced Field Artillery Tactical Data System
ATACMS = Army Tactical Missile System
Bn = battalion
FDC = fire direction center
Janus = interactive, computer-based simulation of combat operations
SCDL = surveillance control data link
TAC = target analysis cell
VSTARS = Virtual Surveillance Target Attack Radar System

Figure 1. ETE Test Conceptual Model

Several components were required to create the ADS-enhanced operational environment used in the ETE Test. In addition to Joint STARS, the ETE Test required a validated simulation capable of generating entities representing the rear elements of a threat force. As discussed in Section 1.3.1, the ETE Test team selected the Janus simulation for this requirement. Also, simulations of the Joint STARS moving target indicator (MTI) radar and synthetic aperture radar (SAR) were needed to insert the simulated entities into the radar stream aboard the E-8C while it was flying a live mission. Other capabilities used to support the test include simulations or subsets of the Army's artillery command and control process and a simulation of the Army Tactical Missile System (ATACMS). Communications among these simulations are accomplished using such doctrinally correct means as the CGS-100, a subsystem of the Compartmented All Source Analysis System (ASAS) Message Processing System (CAMPS), remote workstations (RWSs), and Advanced Field Artillery Tactical Data System (AFATDS) message traffic.

The ETE Test consists of four phases. Phase 1 developed or modified the components that allowed the mix of live and simulated targets at an E-8C operator's console and LGSM operator's console. Phase 2 evaluated the utility of ADS to support DT&E and early OT&E of a C4ISR system in a laboratory environment. Phase 3 transitions portions of the architecture to the E-8C aircraft, ensures that the components function properly, and checks that the synthetic environment properly interacts with the aircraft and the actual LGSM. Phase 4 will evaluate the ability to

perform test and evaluation of the E-8C and LGSM in a synthetically enhanced operational environment using typical operators.

1.3 Phase 1 Overview

This section summarizes Phase 1 test activities which were completed in February 1998. During Phase 1, software and hardware needed to establish the ETE Test ADS environment were developed, modified, and integrated. In addition, Phases 2 through 4 were planned.

The ETE Test ADS environment components developed during Phase 1 included a constructive simulation to provide virtual targets, an E-8C simulation called the Virtual Surveillance Target Attack Radar System (VSTARS), an interface to allow surveillance control data link (SCDL) traffic from VSTARS to be displayed in the LGSM, and an ADS network suitable for integration and testing.

More detailed information on Phase 1 can be found in the *End-to-End Interim Report, Phase 1,* August 1998, available at http://www.JADS.abq.com. (After 1 March 2000 refer requests to HQ AFOTEC/HO, 8500 Gibson Blvd SE, Kirtland Air Force Base, New Mexico 87117-5558, or SAIC Technical Library, 2001 North Beauregard St. Suite 80, Alexandria, Virginia 22311.)

1.3.1 Phase 1 Approach

The JADS ETE Test team developed requirements for a constructive simulation and then evaluated available simulations against these requirements. The Janus simulation, developed and managed by the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC), White Sands Missile Range (WSMR), New Mexico, was selected as the simulation best able to be modified to meet JADS' requirements. TRAC-WSMR expanded the Janus scenario driver into Janus 6.88D, a constructive simulation capable of supporting up to 10,000 individual entities with a distributed interactive simulation (DIS) interface to the ETE Test environment.

The JADS ETE Test team investigated existing simulations of Joint STARS and determined that none of them met the needed fidelity requirements. Northrop Grumman, the developer of the E-8C, created a laboratory emulation of the E-8C radar subsystem and the capability to integrate the E-8C into a synthetic environment. The VSTARS is a laboratory emulation of the E-8C radar subsystem and other aircraft components which can receive synthetic targets from a DIS network and provide the stimulus to display these targets on the Advanced Technology Work Station (ATWS) or LGSM. The radar processor simulator and integrator (RPSI) and the air network interface unit (ANIU) are parts of the VSTARS which are installed on the aircraft. The RPSI receives radar service requests (RSRs) from either an operator workstation (OWS) or a ground station module replica (GSMR) and provides radar target reports (moving target indicator and synthetic aperture radar to the OWS and GSMR.

Phase 1 also included the development of a near real-time simulation of the E-8C synthetic aperture radar. The JADS ETE Test team, through the Advanced Research Projects Agency (ARPA) War Breaker project, conducted a trade study of various existing simulations. The

XPATCHES simulation, developed by Wright Laboratory (Dayton, Ohio) and Loral Defense Systems (Goodyear, Arizona), was selected as the best starting point for the E-8C SAR simulation. Lockheed Martin Tactical Defense Systems, Goodyear, Arizona, developed a SAR simulation emulating the Joint STARS SAR operation. This simulation system, referred to as the Advanced Radar Imaging Emulation System (ARIES), is operationally embedded into Northrop Grumman's radar processor simulation and integrator.

The normal connection between the E-8C and its associated LGSM is through a line-of-sight data link called the surveillance control data link (SCDL). After considerable investigation, the JADS ETE Test team determined that this link could not be easily transmitted via commercial communications lines. Based on discussions among the team, Northrop Grumman, and Motorola, the JADS ETE Test team decided to develop interfaces which transferred the normal message traffic between the E-8C and LGSM rather than attempting to directly transfer the SCDL messages. Northrop Grumman and Motorola developed an interface control document (ICD) which defined this message traffic. Northrop Grumman included the capability in VSTARS to capture these messages and divert them to an Ethernet; Motorola developed an interface unit between the LGSM and an Ethernet. This interface unit links the Ethernet with the internal 1553 databus of the LGSM. Additionally, the interface unit simulates the operation of the ground data terminal requiring the LGSM operator to perform the normal linking process prior to receiving the message traffic from VSTARS.

The Phase 1 network initially connected TRAC-WSMR with the JADS TCAC in Albuquerque, New Mexico, and was then extended from the TCAC to the Northrop Grumman laboratory facilities in Melbourne, Florida. Late in Phase 1, this network grew to include links from the TCAC to Fort Hood, Texas, and Fort Sill, Oklahoma, and a link between Northrop Grumman and Fort Hood.

1.3.2 Phase 1 Results

Phase 1 identified constraints associated with ADS testing. One key constraint was the ability of the DoD infrastructure to support ADS test and evaluation. A measure of this constraint is found in the amount of development required to establish a synthetic environment with which to conduct testing. Phase 1 provided insight onto the development required to support a test of this type. Phase 1 also demonstrated the application of a systems engineering methodology to identify the requirements for ADS components, evaluated the availability of ADS components, and modified or developed the components to meet the requirements.

Extensive testing was accomplished to establish and verify the network configuration. (See Figures 4 and 5 for the final configuration.) Different hardware and software configurations were tested. The use of user data protocol (UDP) packets and their impact on the ETE Test environment was tested. It was determined that UDP imposed some restrictions on network speed. Using UDP the routers were only capable of a throughput of 400 packets per second. UDP is used among all nodes with the exception of the SCDL and the Advanced Field Artillery Tactical Data System (AFATDS) to AFATDS connection.

Data management and analysis methods were examined. The use of data loggers was examined and various loggers were tested. One of these was developed in support of Janus; the other was a product from the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM). Neither the STRICOM or Janus logger provided a high enough time-stamp accuracy, kept processor loads minimized, or provided flexible enough playback accuracy for the data analysis needs of the ETE Test. This led to the development of the JADS logger and the JADS player.

The JADS logger was designed to place a priority on time stamping of protocol data units (PDUs). As PDUs are received they are time stamped. When the processor has time it logs the PDUs. It also has a very minimal user interface that forgoes graphics in favor of processor availability.

The JADS player is able to operate in two modes. Using the first mode, an operator specifies the playback speed multiplier that controls the speed of the PDU playback. The second mode specifies the rate at which the PDUs will be played back. The player can also start playback at any log time.

Synthetic environment analysis data tools were developed to aid in the analysis of PDU test data. They were all incorporated into a single tool called the JADS toolbox. Some of the features include PDU analysis in near real time, predefined analyses and outputs, conversion of binary logfile data to text data, PDU replay, and conversion utilities. The JADS logger was used extensively for the analysis of test data.

Data management techniques explored during Phase 1 will be expanded upon during the remainder of the ETE Test program. It was proven that data collection of large data sets and analysis of the data are possible and even facilitated by the ETE Test environment.

Phase 1 concluded with the creation of a large ADS synthetic environment for C4ISR testing. All the simulators were developed and then connected to create the ETE Test C4ISR testing environment. The environment provided the capability to test multiple systems simultaneously and to determine impacts of one system upon another system. Phase 2 took the environment to the next step and actually used it to conduct a C4ISR test.

2.0 Phase 2 Overview

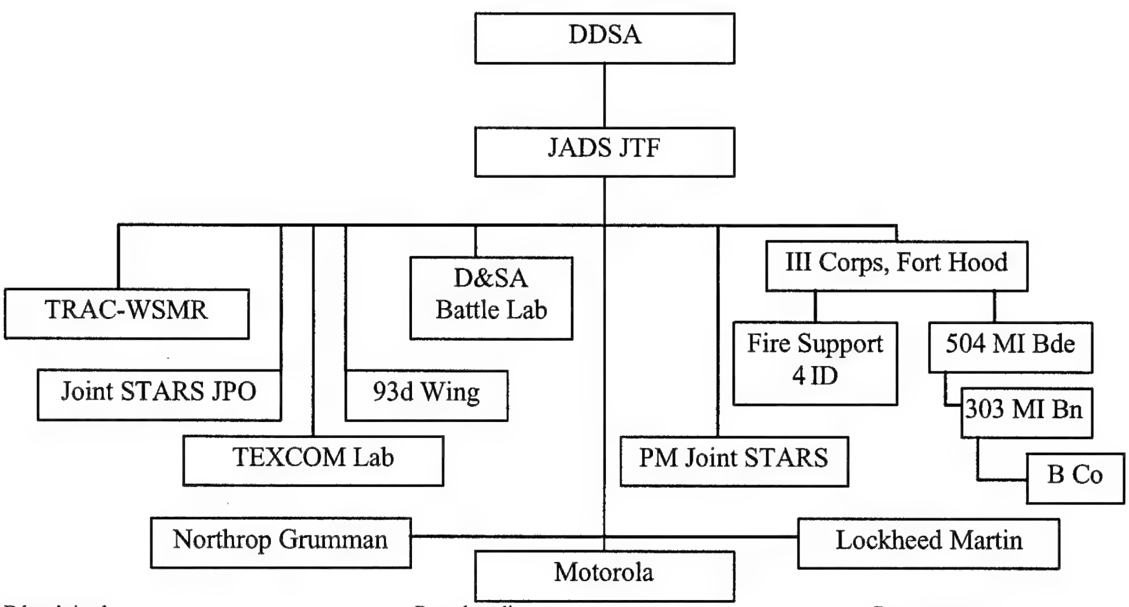
2.1 Phase 2 Purpose

Phase 2 of the ETE Test was designed to determine the utility of ADS to support DT&E and early OT&E of a C4ISR system in a laboratory-based environment.

2.2 Phase 2 Approach

In Phase 2, the E-8C aircraft was represented by ground-based simulations. The Janus model simulated the threat battlefield entities. VSTARS emulated the radar subsystem of the E-8C aircraft and provided the inputs needed to drive target displays on the ATWS (simulating displays onboard the E-8C aircraft) and the LGSM. The resulting radar reports were provided to an actual target analysis cell (TAC) for analysis and target assignment. Fire support missions were tasked using actual AFATDS messages sent to the Tactical Army Fire Support Model (TAFSM) which simulated the launch, flyout, and detonation of an ATACMS missile.

Figure 2 shows the organizational structure for reporting and coordination during Phase 2 of the ETE Test.



Bde = brigade
D&SA = Depth and Simultaneous Attack
JPO = joint program office
TEXCOM = U.S. Army Test and Experimentation Command
Bn = battalion
DDSA = deputy director, system assessment
MI = Military Intelligence
Co = company
ID = infantry division
PM = program manager

Figure 2. ETE Test Organizational Structure

During ETE testing, the roles and responsibilities of these organizations are as follows.

DDSA

The deputy director, system assessment (DDSA) in Washington, District of Columbia:

- Oversees the JADS Joint Test and Evaluation (JT&E)
- Approves JADS financial requirements
- Approves the program test plan (PTP)
- Oversees the analysis and reporting of test results

JADS JTF

The JADS JTF in Albuquerque, New Mexico:

- Conducts overall planning, execution, analysis, and reporting of the test
- Manages funding to accomplish the test
- Develops and evaluates JADS issues, objectives, measures, and related data elements
- Develops and integrates the components of the ETE Test ADS environment
- Establishes necessary communication links with test participants
- Operates the Test Control and Analysis Center during tests
- Works with other organizations in analyzing test data
- Reports interim and final results to OSD

TRAC-WSMR

TRAC-WSMR, New Mexico:

- Develops, tests, and documents Janus 6.88D (an expanded variant of Janus) for JADS
- Assists in integrating Janus 6.88D into the ETE Test ADS environment
- Assists in database conversions
- Assists in developing vignettes
- Assists in verification, validation, and accreditation (VV&A) activities
- Assists in ETE Test execution

TEXCOM Lab

The U.S. Army Test and Experimentation Command (TEXCOM) Lab at Fort Hood, Texas:

- Assists in scenario and vignette development
- Assists in ETE Test execution

D&SA Battle Lab

The Depth and Simultaneous Attack (D&SA) Battle Lab at Fort Sill, Oklahoma:

- Provides and operates the TAFSM and AFATDS
- Assists in the integration of the ETE Test ADS environment
- Assists in VV&A activities and ETE Test execution

U.S. Army III Corps

III Corps Headquarters at Fort Hood, Texas:

- B Company (Co), 303d Military Intelligence (MI) Battalion (Bn), 504th MI Brigade (Bde) supports the conduct of ETE Test Phase 2 and Phase 4 events with LGSM(s) and a target analysis cell (TAC) and assists in the integration of the ETE Test ADS environment
- 504 MI Bde provides a test environment for the ETE Test Phases 2 and 4
- Fire Support 4th Infantry Division (4 ID) provides an AFATDS and personnel to support the ETE Test Phases 2 and 4

Joint STARS Joint Program Office (JPO)

Joint STARS JPO, Hanscom Air Force Base (AFB), Massachusetts, provides access to the Joint STARS JTF and Northrop Grumman.

The Joint STARS JTF of the Joint STARS JPO in Melbourne, Florida:

- Supports conduct of testing in all phases
- Analyzes Joint STARS test results and provides evaluations according to JADS objectives
- Assists in VV&A activities

Northrop Grumman Aerospace Corporation

Northrop Grumman, Electronics and Systems Integration Division in Melbourne, Florida:

- Designed, developed and integrated the radar processor simulation and integrator (RPSI)
- Developed the Virtual Surveillance Target Attack Radar System (VSTARS)
- Conducts and assists in verification and validation (V&V) activities
- Assists in E-8C mission planning
- Operates VSTARS during ETE Test phases

Contracting with Northrop Grumman is conducted through Rome Laboratory in New York.

93d Wing

93d Wing at Robins AFB, Georgia:

- Provided operators during Phase 2 of the ETE Test.

2.3 Test Objectives

The JADS issues, test objectives, and subobjectives for Phase 2 are described below. Each subobjective in turn encompassed one or more test measures. In Section 4 these issues, objectives, subobjectives, and test measures are discussed in terms of their intent, the associated data collection methodology, and operational test results.

JADS Issue 1. What is the present utility of ADS, including DIS, for T&E?

JADS Objective 1-1. Assess the validity of data from tests utilizing ADS, including DIS, during test execution.

JADS Objective 1-2. Assess the benefits of using ADS, including DIS, in T&E. This test objective was broken down into subobjectives. (Subobjective 1-2-1 is not applicable to the ETE Test Phase 2.)

JADS Subobjective 1-2-2. Assess ADS capability to support T&E planning and test rehearsal.

JADS Subobjective 1-2-3. Assess ADS capability to support T&E shortfalls.

JADS Issue 2. What are the critical constraints, concerns, and methodologies when using ADS for T&E?

JADS Objective 2-1. Assess the critical constraints and concerns in ADS performance for T&E. This objective was broken down into subobjectives. (Subobjective 2-1-1 is not applicable to the ETE Test Phase 2.)

JADS Subobjective 2-1-2. Assess network and communications performance constraints and limitations.

JADS Subobjective 2-1-3. Assess the impact of ADS reliability, availability, and maintainability on T&E.

JADS Objective 2-2. Assess the critical constraints and concerns in ADS support systems for T&E. This objective was broken down into subobjectives.

JADS Subobjective 2-2-1. Assess the critical constraints and concerns regarding ADS data management and analysis systems.

JADS Subobjective 2-2-2. Assess the critical constraints and concerns regarding configuration management of ADS test assets.

JADS Objective 2-3. Develop and assess methodologies associated with ADS for T&E. (Subobjective 2-3-1 is not applicable to the ETE Test Phase 2.)

JADS Subobjective 2-3-2. Develop and assess methodologies associated with test execution and control for tests using ADS.

2.4 Phase 2 Methodology

2.4.1 Tactical Vignettes

The tactical vignettes for the ETE Test activities are unclassified. The ETE Test team enhanced a TRADOC-approved, 54-hour corps battlefield simulation (CBS) scenario by replicating an Iraqi corps rear area of operations in Iraq. Table 1 describes the five tactical vignettes created in Janus 6.88D; each vignette is six hours. The following targets were present in the 150 x 150 kilometer (km) Southwest Asia (SWA) terrain box: air defense artillery (ADA) sites, command and control sites, lines of communications (convoys), logistics bases, and concentrations of armor and artillery units.

Table 1. Vignettes Used During ETE Testing

Vignette	Description	Number of Entities
1	Prehostility phase	9,897
2	Preemptive strikes	9,757
3	Hammurabi Division logistical operations	9,904
4	Commitment of the Hammurabi Division	9,781
5	General headquarters (GHQ) depots to corps and divisional logistical operations	9,950

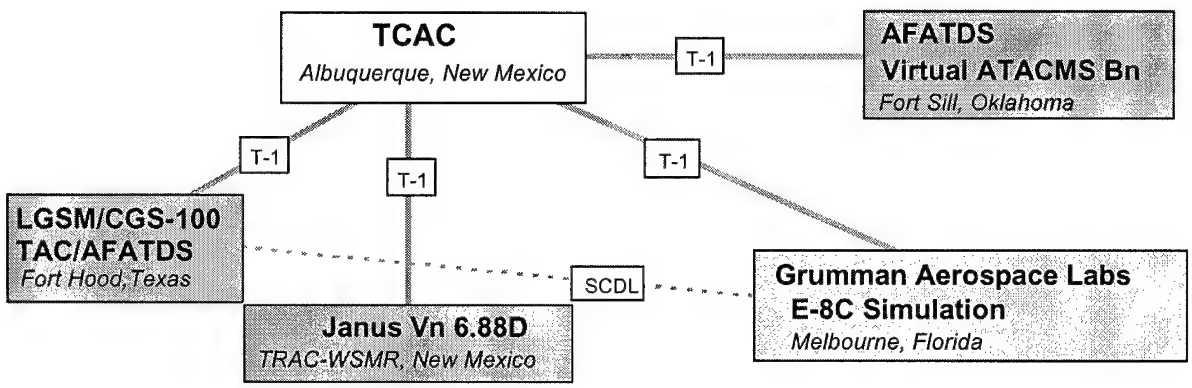
2.4.2 Test Configuration

2.4.2.1 Phase 2 Synthetic Environment

Several components were required to create the ADS-enhanced environment used in Phase 2. Figure 3 provides an overview of the Phase 2 synthetic environment.

The ETE Test used the Janus 6.88D simulation to generate the entities representing the elements in the rear of a threat force. Janus generated entity state PDUs (ESPDUs) for the threat force which were transmitted to the E-8C simulation via the Test Control and Analysis Center (TCAC). TRAC-WSMR provided the Janus scenario feed.

The TCAC in Albuquerque, New Mexico, provided test control. The JADS Network and Engineering (N&E) team monitored the health of the ETE Test network and ensured that adequate data flowed in support of the test.



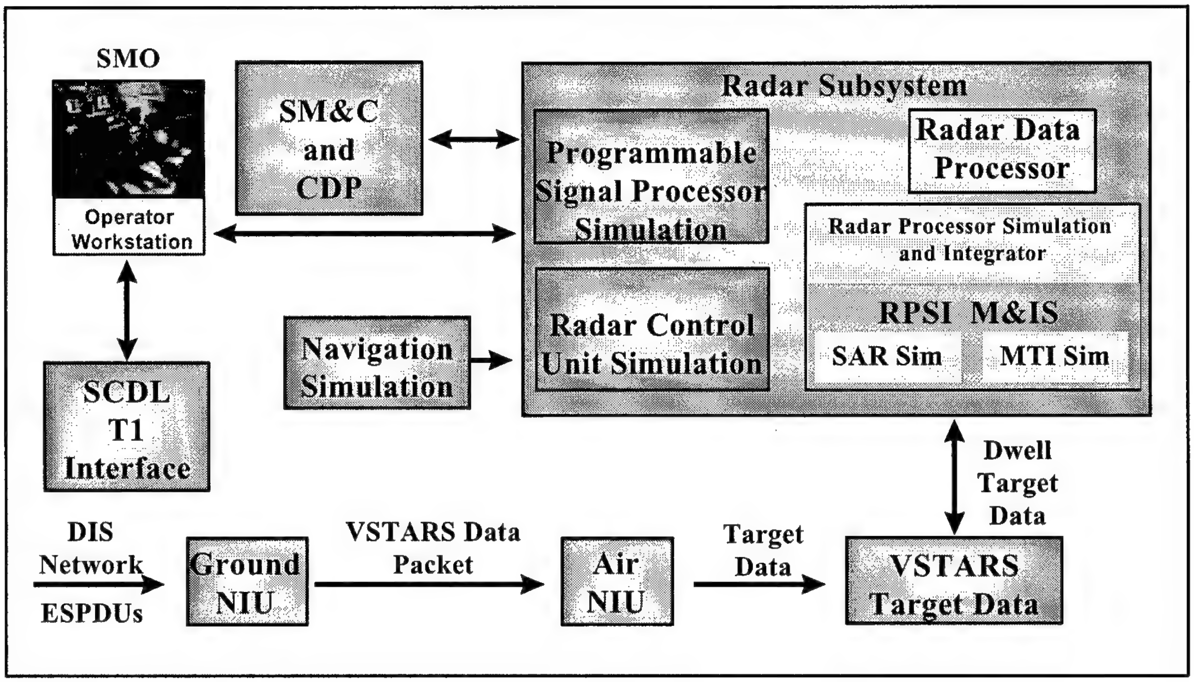
T-1 = digital carrier used to transmit a formatted digital signal at 1.544 megabits per second

Figure 3. ETE Test Phase 2 Synthetic Environment

The Joint STARS E-8C simulation, VSTARS, represents the radar subsystem of the Joint STARS E-8C in a laboratory environment. It is composed of a distributed interactive simulation network interface unit (NIU), a radar processor simulator and integrator (RPSI) that contains the two real-time radar simulations with necessary databases, and various simulations of E-8C processes. Figure 4 provides more information on the VSTARS architecture. VSTARS was operated at the Northrop Grumman Surveillance and Battle Management Systems facility in Melbourne, Florida.

The TAC, fire support (provided by the AFATDS), and a LGSM were stationed at Fort Hood, Texas.

Communications among these C4I systems employed such doctrinally correct means as the CGS-100, a subsystem of the CAMPS, remote workstations, and AFATDS message traffic. The AFATDS messages were transmitted between the AFATDS located at Fort Hood and the AFATDS located at Fort Sill using actual tactical protocols, rather than DIS PDUs. Also, the SCDL messages were transmitted between VSTARS and the LGSM using a dedicated link, a special-purpose interface, and the actual tactical protocols.



CDP - central data processor
M&IS - management and integration software
SM&C - system management and control
SMO - system management officer

Figure 4. VSTARS Architecture

The TAFSM simulation at Fort Sill modeled the ATACMS battalion and sent the fire and detonate PDUs to the Janus 6.88D simulation. In turn, Janus modeled the engagement results and reflected the results in the synthetic environment.

2.4.2.2 Phase 2 Network

Figure 5 provides a more detailed description of the ETE Test network.

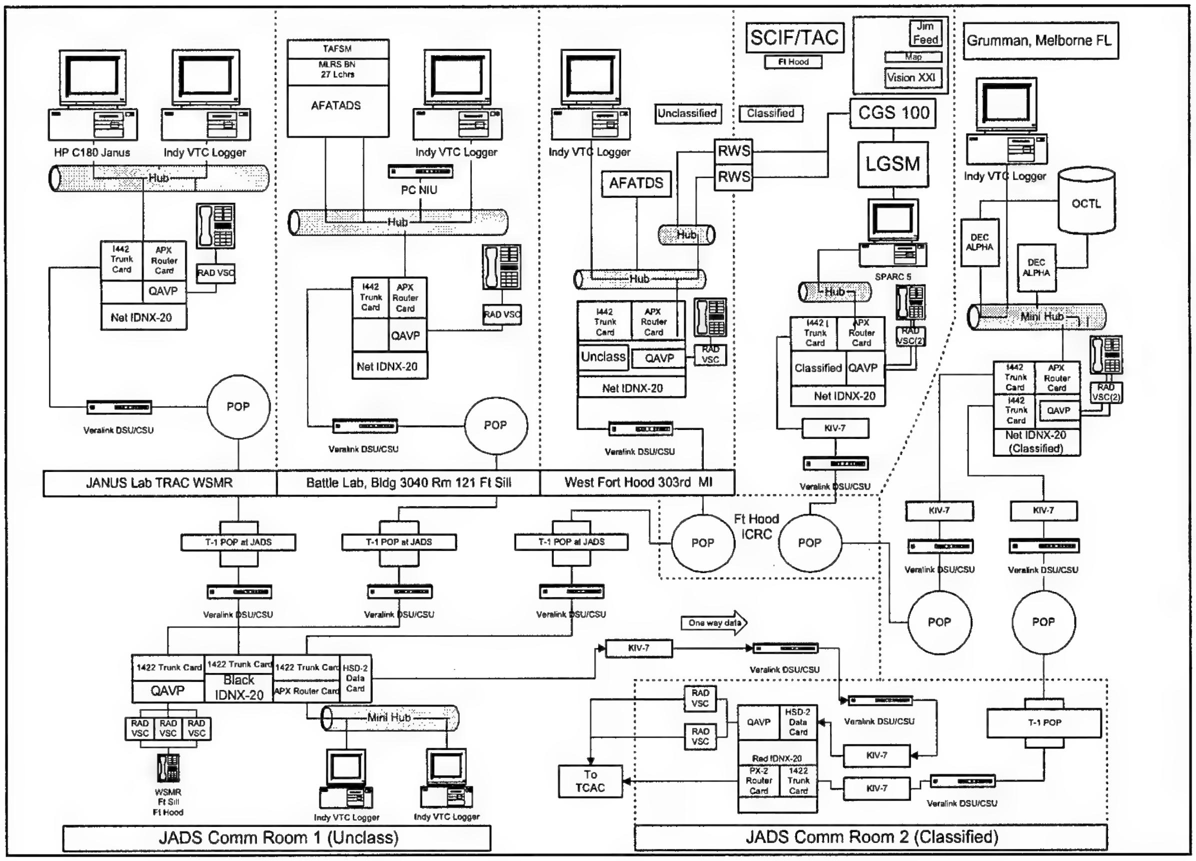


Figure 5. ETE Test Phase 2 Network Diagram

2.4.2.3 Test Control and Monitoring

During Phase 2, ETE Test and Network and Engineering team members performed test control from the TCAC. Test control consisted of three major areas -- network monitoring, communications, and test procedures.

The Network and Engineering team conducted network monitoring in the TCAC using hardware and software tools. The software consisted of commercial products and test-specific tools developed by JADS analyst/programmers. They used the following systems.

Silicon Graphics, Inc. (SGI) Indy - JADS logger
SGI Indy - time server
SGI Indigo - NETVisualyzer™
SUN SPARC 5 - Spectrum™
Line printers

JADS analyst/programmers developed the JADS logger. This software recorded all PDU traffic at individual sites. All nodes, with the exception of Fort Hood, had a JADS logger installed. The logger recorded the receipt of the PDU and time stamped it using an accurate time source. These data were used to analyze PDU transmission performance over the network.

JADS analyst/programmers also developed a time server which provided the accurate time source needed for the JADS logger. The time server was tied to a global positioning system (GPS) receiver located in the TCAC and provided time to all nodes with an accuracy of 100 microseconds. The software also contained monitoring tools to track the time servers performance over an 8-hour test period.

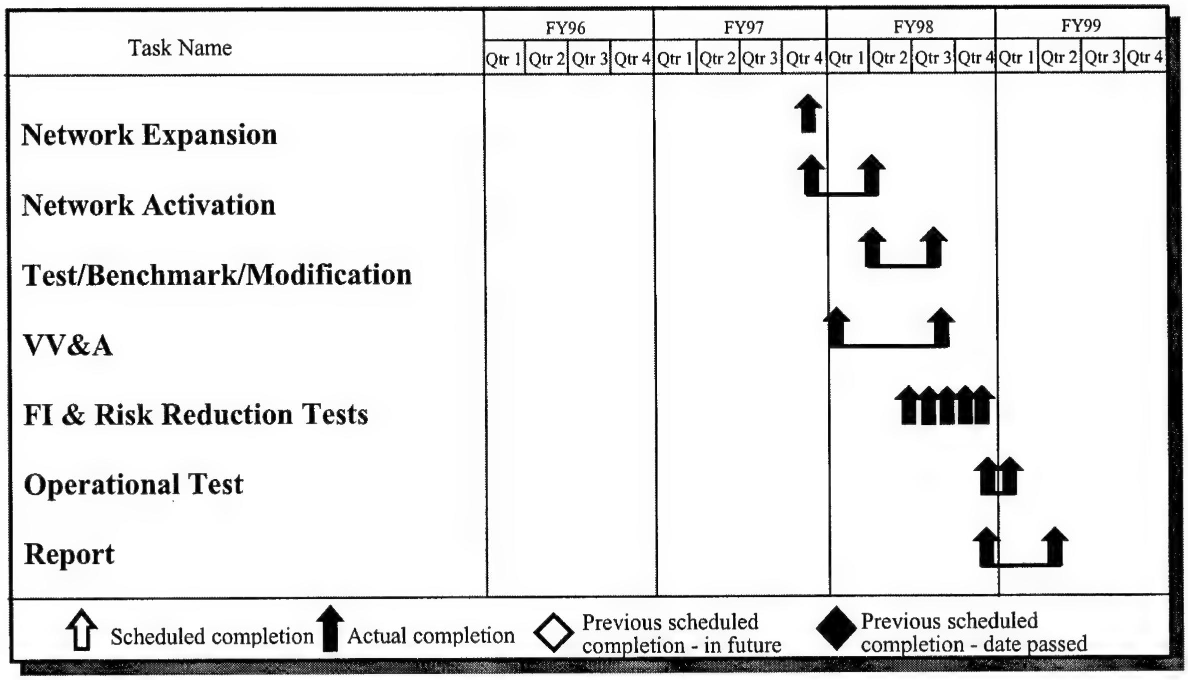
Cabletron Spectrum™, NETVisualizer™, and line printers were used to provide network monitoring. Spectrum™ measured bandwidth utilization. This tool recorded the percentage of bandwidth used, as well as bandwidth loading on a network segment. NETVisualizer™ software displayed real-time bandwidth use in a rolling bar graph format for quick visual reference. The line printers provided a printout of network router status. Any failure or high bit error rate resulted in a printout showing the problem and identity of the offending router.

Communication among the distributed ETE Test nodes was critical. The TCAC provided all needed communication systems. Dedicated phone circuits, residing on the T-1 lines, provided classified and unclassified service. The unclassified line allowed connectivity among the TCAC, Fort Hood, Fort Sill, and TRAC-WSMR. The classified line allowed connectivity among the TCAC, Fort Hood, and Northrop Grumman. These lines allowed the operator to select the desired site, lift the receiver, and connect directly to that site. The TCAC could select multiple sites for conference calls on these lines. In addition to these lines, the ETE Test team used an unclassified conference line to coordinate such test events as network checks and after-action debriefs. This line allowed up to ten participants to connect at one time.

Test procedures were required to provide effective control of all test nodes during test events. The test procedures were in checklist format, which provided for standardization among the distributed nodes. The network checklist was most critical and was used to initialize the network before the test. Other checklists included those used to start up hardware and software at individual nodes, as well as the checklist used by the TCAC test controller to start and stop the overall test.

2.5 Planned Phase 2 Schedule

Figure 6 provides a schedule of the top level tasks for Phase 2 of the ETE Test.



FI = Functionality and Integration Tests #1-4

Figure 6. ETE Test Schedule

2.6 Phase 2 Costs

This report does not describe the costs of the Phase 2 ETE Test. Rather, the report on Phase 4 of the ETE Test will include a Work Breakdown Structure covering the costs of all four phases of the ETE Test. The Phase 4 ETE Test report will be published in summer, 1999.

3.0 Phase 2 Execution Results

Four functionality and integration (FI) tests and one risk reduction test were conducted prior to Phase 2 operational testing.

3.1 ETE Test Functionality and Integration (FI) Tests #1 and #2

FI tests #1 and #2 took place in spring 1998. These two tests focused on establishing the individual nodes and links comprising the ETE Test ADS environment and did not involve any data collection.

3.2 ETE Test FI Tests #3 and #4 and Risk Reduction Test

For all three tests, the ETE Test network consisted of Janus at WSMR, VSTARS at Melbourne, TAFSM at Fort Sill and the LGSM at Fort Hood.

- During each test entity state PDUs (ESPDUs) were broadcast from WSMR to Northrop Grumman via the TCAC. In addition, entity state, fire, detonate, transmit, and signal PDUs were broadcast from Fort Sill to WSMR via the TCAC.

- The Spectrum™ network analysis tool measured bandwidth utilization on the classified links connecting TCAC to Northrop Grumman and Northrop Grumman to Fort Hood.

- Automated data were collected using PDU loggers at the nodes. Taking advantage of the networked nature of the ADS environment, JADS analysts used the file transfer protocol (FTP) to send the data collected at the nodes to JADS. These data were then compressed and converted for analysis on JADS UNIX™-based analysis tools. Operational data were collected using log sheets at each node.

- Draft test procedures were documented before each test. During the test readiness review before each test, the baseline configuration was verified. During each test, the test controller revised and augmented all procedures used to control the test configuration, environment data, and ADS network.

3.2.1 FI Test #3

FI test #3 took place on 26-28 May 1998.

- Janus vignettes 1 and 3 were used to simulate entities and movements for a threat corps rear area of operations. Vignette 1 added 9,897 entities to test execution; vignette 2 added 9,757.

- Testing for most of day one was scrubbed because of a VSTARS malfunction. None of the nodes experienced any problems on days two or three.

- The network was unavailable for testing for 38 minutes out of a scheduled 20 hours and 33 minutes.

- For the TCAC-Northrop Grumman classified link the packet rate averaged 17 packets/second, network load (bandwidth utilized) during active test execution averaged 1%, and peak load never exceeded 30% of link capacity during the three days of testing. Packet rate and network load did increase significantly over the TCAC-Grumman link immediately following active testing each day because PDU logger data files were being imported from Northrop Grumman to the TCAC.

- For the three-day test, total PDU losses and latency were

Node A	Node B	PDUs Sent	PDUs Received	PDUs Lost Total/%	Min/Max/Mean Latency (s)
WSMR	TCAC	934,971	872,297	62,674/6.70%	.026/.120/.029
TCAC	Grumman	872,297	804,567	67,730/7.76%	0.031/.109/.034
Fort Sill	WSMR	2,543	2,513	30/1.12%	---

3.2.2 FI Test #4

FI test #4 took place on 25-26 June 1998.

- Janus vignettes 1 and 2 were used to simulate entities and movements for a threat corps rear area of operations. Vignettes 1 and 2 each added 9,766 entities to test execution.

- Testing on 25 June was scrubbed for less than 1 hour because of the power spike which disrupted ETE testing at WSMR. Both the Fort Hood and Northrop Grumman nodes experienced problems on 26 June with either a router or the Ethernet interface causing the problem. Fort Sill did not experience any problems on either day.

- The network was unavailable for 1 hour and 13 minutes out of a scheduled 12 hours and 55 minutes.

- Packet rate experienced for the classified links averaged around 20 packets/second. Network load (bandwidth utilized) during active test execution averaged 1%, and peak load never exceeded 5% of link capacity during the two days of testing. Packet rate and network load did increase significantly over the TCAC-Grumman link immediately following active testing each day because PDU logger data files were being imported from Northrop Grumman to the TCAC.

- Total PDU losses and latency were

Node A	Node B	PDUs Sent	PDUs Received	PDUs Lost Total/%	Min/Max/Mean Latency (s)
WSMR	TCAC	497,721	473,569	24,152/4.85%	.017/.139/.034
TCAC	Grumman	473,569	457,915	15,654/3.31%	.028/.060/.034
Fort Sill	WSMR	670	624	46/6.87%	---

3.2.3 Risk Reduction Test

The risk reduction test took place on 7-10 and 13 July 1998.

- Janus vignettes 1 and 3 were used to simulate entities and movements for a threat corps rear area of operations. Vignette 1 added 9,897 entities to test execution; vignette 3 added 9,904 entities.

- On 7 July, Fort Sill experienced a minor problem because of a trunk card outage. Testing was interrupted for approximately 1 hour on 8 July because of problems with Janus. Janus froze up, was restarted, and then froze again, causing the test to stop prematurely for that day. Both Fort Hood and Northrop Grumman experienced problems on 9 July because of difficulties with a router/Ethernet interface. Northrop Grumman also experienced a minor problem on 13 July because of a trunk card outage at JADS.

- The network was unavailable for testing for 2 hours and 40 minutes out of a scheduled 35 hours and 7 minutes.

- For the TCAC-Northrop Grumman classified link, packet rate averaged 19 packets/second, network load (bandwidth utilized) during active test execution averaged 1%, and peak load never exceeded 4% of link capacity during the five days of testing. For the Northrop Grumman - Fort Hood classified link, packet rate averaged 34 packets/second, network load averaged 1%, and peak load never exceeded 5% of link capacity. Packet rate and network load did increase significantly over the TCAC-Grumman link immediately following active testing each day because PDU logger data files were being imported from Northrop Grumman to the TCAC.

- Total PDU losses and latency were as follows:

Node A	Node B	PDUs Sent	PDUs Received	PDUs Lost Total/%	Min/Max/Mean Latency (s)
WSMR	TCAC	1,667,371	1,667,283	88/.005%	.007/.142/.041
TCAC	Grumman	1,667,283	1,604,069	63,214/3.79%	.031/.361/.036
Fort Sill	WSMR	3,386	3,385	1/.03%	---

3.3 Operational Test

The operational test portion of the Phase 2 test took place from 14 September through 7 October 1998. The specific measures addressed during the test and the data collected in support of those measures are discussed in Section 4.

4.0 Analysis of Test Objectives

During the operational test portion of Phase 2 of the ETE Test, JADS analysts collected information to address the issues, JADS objectives, and test measures as outlined in the JADS Program Test Plan (PTP) and the ETE Test Data Management and Analysis Plan (DMAP). Only those subobjectives and measures evaluated using Phase 2 results are discussed.

4.1 JADS Issue 1. What is the present utility of ADS, including DIS, for T&E?

This objective determines the extent to which ADS technology can support the T&E of current and future C4ISR systems.

4.1.1 JADS Objective 1-1. Assess the validity of data from tests utilizing ADS, including DIS, during test execution.

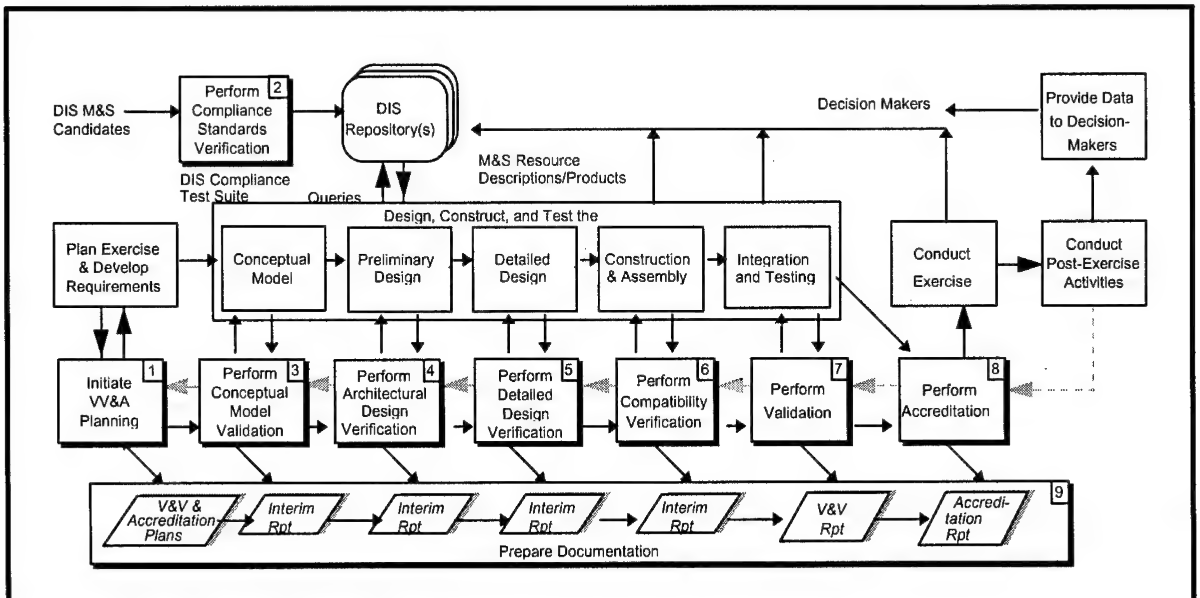
During Phase 2 of the ETE Test, the ETE Test team examined the validity of data from an ADS configuration incorporating the VSTARS simulation, Janus simulation, and other components into a C4ISR architecture.

JADS Measure 1-1-0-1. Degree to which ADS provides valid system under test (SUT) data.

JADS Measure 1-1-0-2. Percentage of ADS data which are valid (data supporting test measures which are timely, accurate, reliable, and otherwise faithfully represent real world systems data).

These two test questions gauge the ability of an ADS environment to provide valid data for a C4ISR system under test. The first measure addresses the validity of the SUT output data which form the data elements for evaluating SUT measures. The second measure provides an assessment of the input data provided to the SUT by the ADS environment.

These measures were primarily addressed through implementation of the Phase 2 V&V plan. Since JADS is a DoD-sponsored joint test, the basis for the Phase 2 V&V was the DIS nine-step VV&A process model and its accompanying *Recommended Practice for Distributed Interactive Simulation -- Verification, Validation, and Accreditation* (draft-21 May 1996). Figure 7 provides an overview of the VV&A process model. Note that this model has been extensively discussed with numerous members of the DIS modeling and simulation community, has been generally accepted by V&V practitioners, and is currently being balloted as a standard.



M&S = modeling and simulation

Figure 7. DIS Nine-Step VV&A Process Model

ETE Test VV&A represented a tailoring and implementation of the nine-step process to a multiservice test of a major system, Joint STARS, augmented with ADS. The tailored ETE Test process model used is described in the Phase 2 V&V reports, *Phase 2 Verification and Validation Results for the End-to-End Test* and *Verification and Validation Report for Phase 2 of the Virtual Surveillance Target Attack Radar System (VSTARS).* (Available from JADS, 2050A 2nd Street SE, Kirtland Air Force Base, New Mexico, 87117-5522. After 1 March 2000 refer requests to HQ AFOTEC/HO, 8500 Gibson Blvd SE, Kirtland Air Force Base, New Mexico 87117-5558, or SAIC Technical Library, 2001 North Beauregard St. Suite 80, Alexandria, Virginia 22311.)

The results from implementing the ETE Test process model for the V&V of the Phase 2 ADS configuration are detailed in the Phase 2 V&V reports and are summarized as follows.

– Verification of Janus 6.88D. The following were verified.
  -- Janus 6.88D was capable of simulating at least 5000 entities with at least twenty-five percent moving.
  -- Janus 6.88D operators were capable of fully interacting with a scenario while it was running. In particular, the Janus site representative interacted with the scenario after several ATACMS impacts by altering the behavior of the surviving entities within the immediate area of the impact.
  -- Janus 6.88D accepted and processed scenarios with a duration longer than eight hours.
  -- Janus 6.88D was capable of proceeding at a pace representative of near real time.
  -- Janus 6.88D was capable of utilizing scenarios conducted upon terrain representing a simulation area of at least 170 km by 170 km.

- Verification of VSTARS. The following were verified.
  - VSTARS received and integrated virtual data from the Phase 2 ADS environment.
  - VSTARS operated in three modes: live only, mixed live and virtual, and virtual only using the standard Joint STARS MTI message format.
  - The radar timeline was not impacted by the MTI simulation.
  - VSTARS processed parameter data in the same format as Joint STARS.
  - VSTARS displayed live SARs in live areas of interest and virtual SARs in both mixed and virtual areas using the standard Joint STARS SAR message format.
  - VSTARS permitted all of the installed operator workstation software to function without abnormal fault messages occurring with minor exceptions.

- Verification of compliance standards (DIS step 2). It was verified that the PDUs emitted by each simulation adhered to the prescribed format.
  - It was verified that Janus 6.88D issued DIS 2.0.4 entity state protocol data units (ESPDUs) that conformed in content and format with the DIS 2.0.4 standards as amended by JADS. (JADS modified the ESPDU time-stamp format from time passed since the beginning of the current hour to milliseconds since the beginning of the vignette. This allowed testers to trace an ESPDU back to a discrete event that occurred within the Janus vignette.)
  - Note that the AFATDS located at Fort Hood communicated directly with the AFATDS at Fort Sill using standard AFATDS message traffic instead of DIS PDUs.

- Verification of compatibility (DIS step 6). It was verified that the modeling and simulation (M&S) components exchanged data and interacted appropriately with each other; that individual components correctly used the common data (e.g., terrain, weather) to generated their portion of the synthetic environment, and that the overall implementation was adequate to address the exercise requirements. It was also verified that the network allowed that transfer of information between the components without corruption and that the individual components shared a common perspective of the virtual reality produced by the exercise. Specific considerations were as follows.
  - It was verified that Janus 6.88D received each ESPDU, fire PDU, and detonate PDU issued to it by the network and took the appropriate action as dictated by the PDU. In particular, Janus correctly identified ATACMS launches initiated by Fort Sill which were outside the scenario terrain box.
  - It was verified that TAFSM accepted artillery missions using AFATDS messages and that TAFSM issued a fire and detonate PDU whenever an ATACMS missile was fired and subsequently detonated.

- Validation of the ETE Test Phase 2 synthetic environment (SE) (DIS Step 7). It was ensured that the integrated simulations were adequate to satisfy the ETE Test requirements such that the behavior and performance of the SE mapped sufficiently to real-world counterparts for the specific ETE Test application. The conclusion that the ETE Test SE was a realistic representation of the real world was based on structured interviews with the VSTARS, LGSM, and TAC operator subject matter experts (SME) participating in the test.

- It was specifically validated that Janus 6.88D represented vehicle behavior to the degree detectable by the Joint STARS, as judged by Joint STARS operator SMEs viewing vehicle movement presented by the Joint STARS operator workstation. Realistic vehicle behavior was achieved after correcting an anomaly observed during the ETE risk reduction test.
  - Portions of convoys missed turns and wandered off into the desert during the entire scenario. The lost portion of the convoy would then jump back into formation after a period of time and resume normal movement.
  - It was determined that when many vehicles were moving Janus was not sending change of state PDUs at a high enough rate. When vehicles are moving, ESPDUs must be sent for any change of state (starting, stopping, turning, or changing speed beyond preset limits) in addition to the normal heartbeat ESPDUs for stationary entities. When Janus did not send enough change of state ESPDUs, VSTARS displayed the vehicle motion in a straight line from the last update.
  - The solution was to turn off the heartbeat prior to the beginning of entity movement so that Janus issued only change of state ESPDUs as the changes occurred. The rate at which Janus sent change of state PDUs was also dramatically increased from a maximum rate of 15 PDUs per second to 100 PDUs per second. This allowed VSTARS to more accurately display the convoys movement on their true path.
- For VSTARS validation, operators with Joint STARS experience performed a two-hour mission using VSTARS and were then asked to compare VSTARS performance with Joint STARS.
  - As with any simulation, differences were noted, but test participants still characterized VSTARS as having the same capabilities and limitations as Joint STARS. They could not identify any VSTARS process or function that limited their ability to perform their mission/job or altered their approach to their mission/job. Results demonstrated a close correspondence between VSTARS and Joint STARS.

Conclusion for JADS Measure 1-1-0-1. The Phase 2 ADS configuration produced valid SUT data. The credibility of the SUT data was enhanced by the use of actual operational hardware, wherever possible (e.g., OWS, LGSM, AFATDS), with actual trained operators. VSTARS was designed so that the only simulated portion is the simulation of the MTI and SAR radar modes within the radar subsystem. Everything else is either integration code or actual E-8C system code. The inputs into VSTARS, except for the target data, are normal inputs into the real radar processor, and the outputs are the actual radar reports. The radar simulations are parallel processes with the radar when live and virtual are mixed and solve the radar equations in order to achieve the required fidelity.

Conclusion for JADS Measure 1-1-0-2. Under normal operations, all input data provided to the SUT (VSTARS and LGSM) by the ADS environment were valid. Network performance and reliability in delivering data to the SUT are analyzed under JADS Objective 2-1.

Since the Phase 2 ADS configuration produced valid SUT data, the utility of this configuration for Joint STARS DT&E and OT&E was evaluated.

Utility for DT&E

This architecture allows the use of VSTARS to conduct developmental testing of all of the other subsystems that comprise Joint STARS, provided that VSTARS is an accurate representation of the radar. Obviously, VSTARS can not be used to conduct developmental testing of the radar subsystem.

As an example, one of the features of the workstation used on the E-8C is an automatic tracker (A-tracker). The A-tracker works off radar reports and, when initiated, will automatically track a designated formation, providing bearing, speed and number of vehicles. Prior to VSTARS, it was necessary to either have a functioning radar (test flight) or a recording of a functioning radar in order to test the A-tracker. Test cases were basically limited to those that could be achieved at Eglin Air Force Base, Florida, with a minimal number of vehicles traveling under peacetime safety restrictions.

Northrop Grumman is currently developing an annual release of the radar software that will incorporate a revised version of the A-tracker software. This provided JADS with the opportunity to ask Northrop Grumman to conduct an ad hoc study, parallel to the normal testing of the new A-tracker software, to determine if it would be possible to use VSTARS to test this software.

Numerous problems in the areas of software integration and scenario generation were experienced because of the ad hoc nature of the study. Additionally, the V&V of VSTARS had not been completed and therefore no results could be used as documentation for the annual release. Despite these problems, several lessons were learned from this study relating to utility of VSTARS for DT&E.

- Test cases could be "flown" using VSTARS whenever needed with as many repetitions as desired. This was possible without competing for scarce test aircraft and range resources.

- There was a potential for enormous cost savings. One tester and two computers in a lab vice the aircraft, testers, crew and range assets required for a live test.

- Any conceivable test case could be "flown" in the laboratory without worrying about safety or limited assets provided the appropriate scenario generator was available.

- Bad software could be quickly discarded and new software could be tried the next day.

- Most importantly, when a live test is flown, as it must be, the testers can be reasonably sure that they will get the maximum value from the flight and test conditions.

Utility for OT&E

The utility of this configuration for Joint STARS OT&E was evaluated by determining which measures from the Joint STARS Multiservice Operational Test and Evaluation (MOT&E) Plan[1] could be supported. Appendix B (available under separate cover from JADS JTF) identifies which Joint STARS MOT&E measures could be evaluated using the Phase 2 ADS configuration. For comparison, the measures which were addressed during the contingency operations[2] were also identified.

Results in Appendix B are summarized as follows.

- The measures for critical operational issue (COI)-1 (Does Joint STARS perform its tactical battlefield surveillance mission?) involving the performance of the E-8C radar in its operational environment cannot be evaluated. In Phase 2, a simulator is used to represent the E-8C radar subsystem. As a result, the 13 radar measures of performance (MOPs) could not be evaluated in the Phase 2 configuration. The Phase 2 configuration can be used to evaluate 4 out of 5 nonradar MOPs supporting COI-1. However, all three measures of effectiveness (MOEs) for COI-1 can at least be partially evaluated using the Phase 2 configuration.

- As for COI-1, the measures for COI-2 (Does Joint STARS support the execution of attacks against detected targets?) involving the performance of the E-8C radar in its operational environment cannot be evaluated using the Phase 2 configuration. The Phase 2 configuration can be used to evaluate 8 out of 13 nonradar MOPs supporting COI-2. However, all three MOEs for COI-2 can at least be partially evaluated using the Phase 2 configuration.

- The Phase 2 ADS configuration can support evaluation of the single MOE for COI-3 (Does Joint STARS provide timely and accurate information to support battlefield management and target selection?) and 1 out of 2 MOPs for COI-4. (Can the Joint STARS system be sustained in an operational environment?)

- The Phase 2 ADS configuration can support the evaluation of 6 out of 13 of the additional nonradar effectiveness measures.

- Since the Phase 2 ADS configuration utilizes an actual ground station module (GSM), 8 out of 27 suitability MOPs involving the GSM could be evaluated.

- The Phase 2 ADS configuration does not involve the actual air platform and could address only 1 out of 8 human factors measures.

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[1] *Joint Surveillance Target Attack Radar System (Joint STARS) Multiservice Operational Test and Evaluation (MOT&E) Plan*, Air Force Operational Test and Evaluation Center, Kirtland Air Force Base, New Mexico, 21 February 1995.

[2] *Joint Surveillance Target Attack Radar System (Joint STARS) Contingency Operations Test and Evaluation (COT&E) Plan*, Air Force Operational Test and Evaluation Center, Kirtland Air Force Base, New Mexico, 1 December 1995.

- The Phase 2 ADS configuration cannot address any of the six software measures since an operational Joint STARS software load was not used.

In summary, the Phase 2 ADS configuration could evaluate 15 out of 45 effectiveness MOPs (including two MOPs not evaluated during the contingency operations) and all eight effectiveness MOEs. Further, the Phase 2 ADS configuration could be used to evaluate the GSM suitability MOPs (8 out of 27 suitability MOPs). However, this configuration would not be useful for evaluating the human factors or software measures.

4.1.2 JADS Objective 1-2. Assess the benefits of using ADS, including DIS, in T&E.

4.1.2.1 JADS Subobjective 1-2-2. Assess ADS capability to support T&E planning and test rehearsal.

JADS Measure 1-2-2-4. Degree to which pretest exercise of data reduction and analysis routines using ADS improved test preparations.

This measure evaluated the impact of ADS technology on data reduction and analysis routines. In support of this test question, the ETE Test analysts conducted interviews with test team members involved in data reduction and analysis during the Phase 2 test and test rehearsals.

The Phase 2 data reduction and analysis methodology was based on procedures successfully used in earlier JADS tests. Procedures used during the FI and risk reduction tests, as well as during the Phase 2 operational test (OT), were basically unchanged from those used previously.

Table 2 describes the estimated number of hours spent on rehearsing data reduction and analysis procedures in each of the functionality and integration (FI) tests, as well as during the risk reduction test. These rehearsals were focused on ensuring that the proper tools and procedures were in place for each pretest. Phase 2 pretest activities provided several occasions for JADS analysts to practice the data reduction and analysis procedures used later in the operational test. The times presented in Table 2 do not include time spent on either data collection or report writing.

Data reduction and analysis activities in Phase 2 were aided by the use of the JADS Analysis Toolbox. Developed over the course of earlier JADS tests, the toolbox is a set of software routines written in the C++ programming language and integrated into a single user interface. The toolbox can be employed to develop tables and plots of PDU data in near real time. After the test, toolbox users can replay or get selected data in a text-readable format from JADS logfiles and obtain plots and tables of PDU statistics. The PDU statistics, in turn, include the number of PDUs received, the number of each type of PDU received, and the rate at which PDUs are being received. An important point is that the ETE Test logfiles were larger than earlier JADS test logfiles. Modifications were made to the toolbox software to minimize the impact of the size of the ETE Test logfiles on file access time, as well as on the amount of memory needed for calculations. (For further information on the JADS Analysis Toolbox, please contact the JADS

program office or visit the JADS website at http://www.jads.abq.com where it will be available until September 2000. After that it will be available at HQ AFOTEC/HO, 8500 Gibson Blvd SE, Kirtland Air Force Base, New Mexico 87117-5558 and at the SAIC Technical Library, 2001 North Beauregard St. Suite 800, Alexandria, Virginia 22311.)

Table 2. Time Spent on Pretest Data Reduction and Analysis Rehearsals

Data Type	FI #1	FI #2	FI #3	FI #4	Risk Reduction Test
PDU Data	8 hrs	8 hrs	8 hrs	8 hrs	16 hrs
Latency	8 hrs	8 hrs	8 hrs	8 hrs	16 hrs
Network Availability	4 hrs	4 hrs	4 hrs	4 hrs	4 hrs
ADS System Availability	4 hrs	4 hrs	4 hrs	4 hrs	4 hrs
Bandwidth			2 hrs	2 hrs	3 hrs
Packet Rate			1 hr	1 hr	3 hrs
Other OT Test Measures					60 hrs

The ETE Test Phase 2 also demonstrated the unique advantages of an ADS environment with respect to data reduction and analysis processes.

- For both ADS and conventional tests, these routines are typically developed prior to the actual test events. For non-ADS tests, actual test assets (i.e., flight time) may need to be expended in order to produce the data needed to test these routines. In contrast, the JADS analysts were able to exercise their data reduction and analysis routines using data from the FI and risk reduction tests accomplished prior to Phase 2 OT testing. This early availability of test data enabled the analysts to check out and refine these procedures and prevented the loss of critical test data from the actual Phase 2 OT test.

- If an ADS test team emphasizes the early exercise of data reduction and analysis routines during pretest rehearsals, it can reduce or eliminate the loss of critical data and expenditure of valuable test assets during subsequent actual testing.

- In addition, the pretest rehearsals offered testers the opportunity to improve the data gathering process. For example, when beginning Phase 2, the ETE Test team intended to log all operator actions in the LGSM. As the test progressed, the JADS analysts realized that their efforts to obtain data from the LGSM operators were hampering the latter's abilities to provide accurate and timely information to the TAC. As a result, the JADS analysts automated most of the data collection and retrieved it at the end of the mission.

- The networked nature of an ADS environment provides a built-in means to support data management. During the FI and risk reduction tests prior to the Phase 2 operational test, the ETE Test team took advantage of this capability and was able to speed the transport of test data from the nodes to a central collection and analysis point.

JADS Measures 1-2-2-5 and 1-2-3-24. Degree to which ADS can be used for tactics development prior to test execution. Degree to which ADS can ensure that correct techniques and procedures are used.

These measures determined if the techniques and procedures used by the test participants to obtain and disseminate information on target enemy forces could be enhanced in any way using an ADS environment. In a broader context, JADS analysts wanted to determine if the ADS test environment could be used to correct, refine, and change tactics, techniques, and/or procedures prior to exercising a live test. During the rehearsal tests, prior to the Phase 2 operational test, JADS analysts recorded the flow of information from the TAC to the LGSM and all fire missions initiated by the TAC battle captain and executed using ATACMS. After each of these tests, a follow-up interview was conducted with the TAC battle captain to determine the targeting process used and to assess the potential of using ADS to improve current techniques and processes and develop tactics.

ADS testing also allowed the operators to use the tactical scenarios and make real-world decisions concerning their surveillance and targeting efforts. The JADS analysts noticed a great improvement over time in the operators' abilities to focus on certain aspects of the scenario and in their increased use of the tools available to them to obtain more information on the entities they were observing.

The increased test time provided by an ADS environment appears valuable in allowing C4ISR system operators and end users to confirm and refine current tactics and to experiment with "what if" scenarios and new tactics. This feature will be further examined in the Phase 4 test.

4.1.2.2 JADS Subobjective 1-2-3. Assess ADS capability to support T&E shortfalls.

JADS Measures 1-2-3-1, 1-2-3-17, and 1-2-3-28. Degree to which ADS can add test articles to test execution, provide for more representative force levels, and increase the number of simulation entities.

Conventional T&E typically suffers from an inadequate number of entities. Typical tests may have to be conducted in conjunction with training missions in order to acquire possibly hundreds of assets. However, testers will then have only minimal control over test specifics and must base their test on the training scenario being executed.

In contrast, Table 3 shows that the Janus simulation provided thousands of entities for each vignette in Phase 2.

Phase 2 results imply the following benefits of ADS-based testing.

- An ADS environment using validated simulations can provide more realistic force levels than those offered by conventional tests, i.e., levels otherwise unavailable because of cost restrictions.

- C4ISR system testers can tailor the simulation entities operating in the ADS environment to closely reflect the forces expected in operational theaters, thus further increasing the relevance of the collected test data.

- ADS allows testers to have more control over the specific aspects of the scenarios of interest and to expand their test concept and design. A typical constraint to test concept development is the number and types of units readily available for a test. For example, a conventional test may require the use of a battalion of troops, but because of a prior commitment or cost, these personnel may not be available. In contrast, ADS allows testers to create a virtual battalion and to test their concepts with a minimum number of personnel and equipment.

Table 3. Entity Count Per Vignette

Vignette	Number of Entities
1	9,897
2	9,757
3	9,904
4	9,781
5	9,950

JADS Measure 1-2-3-3. Degree to which ADS overcomes performance restrictions.

ADS is helpful in simulating maneuver scenarios that overcome shortfalls associated with traditional testing. This technology increases test robustness by providing the capability for adding large numbers of assets. ADS simulations can depict such unsafe conditions as convoy vehicles driving across rugged or restricted terrain under wartime conditions. Finally, this technology frees the tester from the constraints of environmental restrictions. Without the benefits of ADS-enhanced testing, it would be almost impossible to instrument and maneuver a corps-size element.

JADS Measure 1-2-3-4. Degree to which ADS overcomes the traditional T&E shortfall of insufficient battlespace.

ADS technology can easily eliminate the conventional testing disadvantage of insufficient battlespace. For example, the National Training Center occupies about one thousand square

miles. In contrast, the battlespace for Phase 2 of the ETE Test was almost ten times larger. In fact, ADS technology is capable of supporting even larger battlespaces.

JADS Measures 1-2-3-7 and 1-2-3-12. Degree to which ADS overcomes the lack of systems for interoperability testing associated with traditional T&E and can increase the number of systems for compatibility evaluation.

There were many incompatibility problems among the fielded real systems that persisted well into the risk reduction test. The TAC had never had the opportunity to perform this function, under tactical conditions in a doctrinally correct manner, prior to the risk reduction test. Use of the risk reduction test ADS environment allowed these incompatibility problems to be identified and resolved.

Phase 2 results show that ADS can link similar systems to perform simultaneous testing and training at various locations. The ETE Test Phase 2 used only one LGSM to provide intelligence to the TAC at Fort Hood. However, the potential exists for linking numerous LGSMs at different military installations and simultaneously conducting the same type of test and training.

JADS Measure 1-2-3-9. Degree to which ADS increases the number of test events.

Using ADS, testers can replicate a test, as well as test for longer periods of time. During the Phase 2 test, the ETE Test team was able to test for thirty hours within a 5-day period. A test using real assets, and of similar duration, would be very expensive and probably even impossible.

JADS Measure 1-2-3-31. Degree to which ADS can represent joint/combined operations and capabilities.

ADS can realistically portray joint operations among military elements of the same nation. For example, the Phase 2 test employed a mix of Air Force and Army personnel located at different facilities successfully simulating a C4ISR system interacting with ground-based units. Given the necessary planning and resources, ADS could also represent combined operations between forces of two or more allies.

JADS Measure 1-2-3-36. Degree to which ADS can increase personnel resources.

The duties of all personnel involved in the setup and execution of the Phase 2 test were examined to determine which personnel would not have been required for a traditional test. In addition, the number of personnel participating in the test, due solely to ADS-specific requirements, was documented.

The ETE Test Phase 2 results did not provide any set formula for forecasting personnel needs. Rather, the exact personnel requirements for C4ISR system testing in an ADS environment appears to vary from test to test. With this caveat in mind, and using just the ETE Test team requirements, an ADS environment does not appear to add to the personnel needs of a C4ISR test. Six JADS personnel are continually involved in ETE Test management and planning, a

number equivalent to the staff needed to direct the day-to-day operations of a conventional C4ISR test of the same magnitude. Thirteen people were involved in test monitoring and data collection at the various ETE Test nodes during the actual execution of the Phase 2 FI, risk reduction, and operational tests. Given the distributed nature of C4ISR systems, a similar number of people would be needed in a comparable, traditional C4ISR test. Two Network and Engineering personnel were needed for network support during the execution of Phase 2, and two analysts handled the subsequent data analysis and reduction. However, a conventional C4ISR SUT would probably need at least two network engineers because of its distributed nature, and maybe more, since it might not be as reliable as the ETE Test Phase 2 network. In addition, the C4ISR environment would likewise require a minimum of two data analysts.

4.2 JADS Issue 2. What are the critical constraints, concerns, and methodologies when using ADS for T&E?

The ETE Test Phase 2 demonstrates that there are no real technical barriers to using an ADS environment to provide a realistic test environment for a C4ISR system. This is due to the high reliability of the network architecture underlying an ADS environment and the dramatic increases in computer processing and storage capabilities over the past few years. Rather, the key constraints to ADS testing are time and money: How soon do you need results? How much are you willing to spend on development?

The following paragraphs discuss constraints and concerns in detail.

4.2.1 JADS Objective 2-1. Assess the critical constraints and concerns in ADS performance for T&E.

4.2.1.1 JADS Subobjective 2-1-2. Assess network and communications performance constraints and limitations.

JADS Measures 2-1-2-2 and 2-1-3-3. Percentage of ADS trials canceled or otherwise not used due to network problems. Percentage of trials in which network connections were lost long enough to require trial cancellation.

For these measures, the network was defined as including all software and hardware used for connecting the distributed sites and all loggers and instrumentation used for recording network data. NIUs were considered part of the individual simulations and not part of the network.

For each trial, an execution log was maintained at each node. The data collectors annotated all problems encountered, as well as their causes. A test controller log also documented the overall status of the network and test trials. In addition, network monitoring tools were used to monitor the status of all network links between nodes. Any problems detected by the monitoring tools were documented via line printers in terms of a brief explanation of the problem, the time, and the link(s) involved.

No trials were canceled, or not used, because of network problems. However, two trials were postponed when the agency contracted to provide network service inadvertently terminated use of the T-1 line at the Northrop Grumman node. The coincidence of a hurricane hitting the Florida and Gulf coasts during the same timeframe delayed the reactivation of this link. As a result, the test was extended two days after the scheduled test period. Table 4 shows the dates of the trials and their test times.

Table 4. ETE Test Phase 2

Trial	Vignette	Test Time	Comments
28 Sep			Postponed to 5 Oct
29 Sep			Postponed to 6 Oct
30 Sep (Day 1)	3	7 hrs, 1 min	
1 Oct (Day 2)	4	7 hrs, 4 mins	
2 Oct (Day 3)	5	7 hrs, 7 mins	
5 Oct (Day 4)	1	7 hrs	
6 Oct (Day 5)	2	7 hrs, 15 mins	

JADS Measure 2-1-2-3. Average and peak bandwidth used by link.

This measure provided an indication of bandwidth use and packet rate during the OT. Although bandwidth utilization was not expected to exceed capacity, the utilization rate was documented to provide other ADS testers with an indication of the amount of needed bandwidth. The packet rate data are also included because of their potential value to other ADS testers.

Data were collected using the Spectrum™ network analysis tool. Spectrum™ provided the capability to study multiple aspects of network link performance, including packet rate and percentage of bandwidth utilized. A polling rate of fifteen seconds was used in the collection of these data.

Once all the data were gathered, the JADS analysts consolidated the data by network link. These data were then used to calculate daily packet rate and bandwidth values (maximum and average) for each link. The bandwidth values were provided by Spectrum™ as the percentage of bandwidth available on the T-1 line. A T-1 line has a normal bandwidth of 1.544 megabits per second (Mbps). For the ETE Test, some of the bandwidth of the T-1 line was reserved for voice traffic, leaving a maximum bandwidth available of 1.344 Mbps.

Table 5 shows average and maximum performance values for the classified network links monitored during the five days of active ETE Phase 2 testing.

Packet rate and bandwidth utilized remained fairly constant across the five-day test period. The packet rate and bandwidth utilization rate experienced over the TCAC-Northrop Grumman link averaged approximately 18 packets per second and less than 1%, respectively. The packet rate experienced over the Northrop Grumman-Fort Hood link averaged approximately 34 packets per

second with an average utilization rate of about 1% of capacity. The maximum packet rate over the TCAC-Northrop Grumman link was 120 packets per second resulting in a 20% peak load experienced. However, these maximum values appeared to be anomalous, caused by the reestablishment of the Janus heartbeat following a crash; the more typical maximum values were 37 packets per second and 2% bandwidth utilization. The maximum packet rate experienced over the Northrop Grumman-Fort Hood link was 102 packets per second resulting in a 5% bandwidth utilization rate. These maximum values were consistent from day to day. These data for the two links show the relatively small bandwidth utilization experienced during the Phase 2 test with the maximum packet rate experienced still leaving nominally 95% of the 1.344 Mbps of bandwidth available for use. Future ETE tests will use the available bandwidth to facilitate a higher heartbeat by sending more frequent entity state PDU updates from the Janus simulation.

Table 5. Link Performance Characteristics*

Day	Node A	Node B	Load		Packet Rate	
			Average	Maximum	Average	Maximum
1	T	G	0.33%	2.0%	16.93/sec	34.0/sec
	G	H	0.66%	5.0%	29.18/sec	98.0/sec
2	T	G	0.87%	2.0%	18.60/sec	34.0/sec
	G	H	0.98%	5.0%	34.64/sec	102.0/sec
3	T	G	0.63%	20.0%	18.07/sec	120.0/sec
	G	H	1.27%	5.0%	36.64/sec	97.0/sec
4	T	G	0.54%	2.0%	17.99/sec	37.0/sec
	G	H	1.43%	5.0%	39.39/sec	97.0/sec
5	T	G	0.53%	2.0%	18.0/sec	33.0/sec
	G	H	0.99%	5.0%	28.87/sec	98.0/sec
Total	**T**	**G**	**0.58%**	**20.0%**	**17.92/sec**	**120.0/sec**
	G	**H**	**1.07%**	**5.0%**	**33.74/sec**	**102.0/sec**

T = TCAC G = Northrop Grumman H = Fort Hood

* Table refers only to active test time during which PDU loggers were recording data.

JADS Measures 2-1-2-5, 2-1-2-6, and 2-1-2-7. Percentage of time PDUs were received out of order by a network node. Percentage of total PDUs required at a node that were delivered to that node. Average and peak data latency between ADS nodes.

The flow of PDUs to and from each node was recorded using loggers installed as part of the network architecture. The loggers specifically recorded the time and order that the PDUs were transmitted and received at each node.

The raw logger data were transformed and reduced for analysis to determine out of order PDUs, duplicate PDUs, lost PDUs, and PDU latency. These data were then used to calculate the percentage of out of order, duplicate, and lost PDUs at each node for each vignette and for the test as a whole. The minimum, maximum, and mean latency of PDUs were also computed. JADS analysts accomplished these calculations using UNIX®-based software tools created by JADS programmers. Results for these measures are given in Tables 6 and 7.

Table 6. Vignette PDU Data

Vignette	Node A	Node B	PDUs Sent	PDUs Rec'd/ Percent Rec'd	PDUs Lost/ Percent Lost
1	W	T	43,125	43,123 99.995%	2 0.005%
	T	G	43,123	43,123 100%	0 0%
	S	W	2,607	2,606 99.962%	1 0.038%
2	W	T	80,180	80,145 99.956%	35 0.044%
	T	G	80,145	80,121 99.970%	24 0.030%
	S	W	2,690	2,690 100%	0 0%
3	W	T	81,695	81,677 99.978%	18 0.022%
	T	G	81,677	81,603 99.909%	74 0.091%
	S	W	2,665	2,665 100%	0 0%
4	W	T	94,267	94,254 99.986%	13 0.014%
	T	G	94,254	94,205 99.948%	49 0.052%
	S	W	3,040	3,040 100%	0 0%
5	W	T	82,987	82,960 99.967%	27 0.033%
	T	G	82,960	82,907 99.936%	53 0.064%
	S	W	2,743	2,743 100%	0 0%
Total	W	T	382,254	382,159 99.975%	95 0.025%
	T	G	382,159	381,959 99.948%	200 0.052%
	S	W	13,745	13,744 99.993%	1 0.007%

W= WSMR T = TCAC G = Northrop Grumman S = Fort Sill

Table 7. Vignette Latency Data

Vignette	Node A	Node B	Latency (seconds)		
			Minimum	Mean	Maximum
1	W	T	0.020	0.040	0.145
	T	G	0.051	0.056	0.605
	S	W	0.032	0.034	0.383
2	W	T	0.018	0.037	0.139
	T	G	0.050	0.057	1.090
	S	W	0.033	0.034	0.381
3	W	T	0.020	0.041	0.079
	T	G	0.051	0.058	1.080
	S	W	0.030	0.035	0.392
4	W	T	0.016	0.039	0.084
	T	G	0.051	0.056	0.580
	S	W	0.031	0.036	0.396
5	W	T	0.021	0.038	0.079
	T	G	0.050	0.059	0.585
	S	W	0.031	0.034	0.361
Total	W	T	0.016	0.039	0.145
	T	G	0.050	0.057	1.090
	S	W	0.030	0.035	0.396

W= WSMR T = TCAC G = Northrop Grumman S = Fort Sill

Table 6 shows the PDU data for each vignette by node; there were no duplicate or out of order PDUs. Table 7 provides the latency data for the vignettes broken down into the individual network links between nodes. These tables indicate the high reliability of the network in passing PDUs and the network ability to maintain stable latencies during the Phase 2 test.

The PDU data in Table 6 show total PDU loss rates of 0.025, 0.052, and 0.007 percent for the WSMR-TCAC, TCAC-Northrop Grumman, and Fort Sill-WSMR links, respectively. Note that the total loss rate for ESPDUs generated by Janus being delivered from the WSMR node to the Northrop Grumman node (the node requiring them) is 0.077 percent (or 295 PDUs lost out of 382,254 PDUs sent). These loss rates were insignificant and did not affect the validity of the Phase 2 OT results.

The latency data in Table 7 show that the average latency for a given link was very stable over the five days of testing, varying by only five percent or less. Note that the latency over the TCAC-Northrop Grumman link had maximum values exceeding one second. However, these were only transient values and did not significantly affect the average latency (which varied by only about 3% over the five days). The average total latency for the ESPDU data to travel from the WSMR node to the Northrop Grumman node was less than 100 milliseconds and had no effect on the validity of the Phase 2 OT results.

JADS Measure 2-1-3-6. Average downtime due to ADS network failures.

This measure identified the impact of network failures on the OT. During Phase 2, logs were kept to record all network problems, the start time and duration of the problems, and problem resolution. In addition, network monitoring tools were used to monitor the status of all network links between the nodes. Any problem detected by the monitoring tools was documented via line printers in terms of a brief explanation of the problem, the time, and the link(s) involved.

During the five days of operational testing, only three network outages were experienced, resulting in 8 minutes of downtime (Table 8).

Table 8. Network Downtime

Day	Time Scheduled for Testing	Time Network Unavailable for Testing	% of Time Network Unavailable	Reason Unavailable
1	7 hrs, 1 min	3 mins	0.71%	Router down at Fort Hood
2	7 hrs, 4 mins	0 mins	0%	
3	7 hrs, 7 mins	3 min	0.70%	Router down at Northrop Grumman
4	7 hrs	0 min	0%	
5	7 hrs, 15 mins	2 mins	0.46%	Router down at Fort Hood
Total	**35 hrs, 27 mins**	**8 mins**	**0.38%**	

4.2.1.2 JADS Subobjective 2-1-3. Assess the impact of ADS reliability, availability, and maintainability on T&E.

JADS Measures 2-1-3-1 and 2-1-3-5. Percentage of trials delayed, rescheduled, and/or redone due to ADS systems (exclusive of network) unavailability. Mean operating time between ADS system failures (severe enough to require trial cancellation).

These measures determined the availability of ADS nodes including the NIUs and the impact of node failures on Phase 2 testing.

For each trial, an execution log was maintained at each node. The data collectors annotated all problems encountered with the ADS systems, along with their causes. A test controller log was also maintained to document the overall status of the trials.

Once the Phase 2 test network was available, no trials had to be rescheduled. In addition, there were no significant delays and only minor ADS system failures. Table 9 lists the reported ADS system failures, along with the time needed to resolve these interruptions and their impact on testing.

Table 9. ADS System Failures

Day	Failure	Resolution	Duration	Test Time	Impact on Test
28 Sep	Network unavailable				Trial rescheduled
29 Sep	Network unavailable				Trial rescheduled
1	One LGSM console crashed at Fort Hood	Console rebooted	17 mins	7 hrs, 1 min	Only one workstation in use (minimal impact); no PDUs lost
2	No failures	N/A	N/A	7 hrs, 4 mins	N/A
3	Power outage at Fort Hood	LGSM rebooted once power restored	21 mins	7 hrs, 7 mins	Fire mission coordination delayed (minor impact); no PDUs lost
	Janus locked up at WSMR	Janus rebooted	13 mins		Trial stopped and restarted at point of lockup; no PDUs lost
	VSTARS crashed at Northrop Grumman	VSTARS rebooted	10 mins		Updates and coordination with Fort Hood interrupted; no PDUs lost
4	Janus locked up at WSMR	Janus rebooted	24 mins	7 hrs	Trial stopped, then restarted at point of lockup; no PDUs lost
	Janus locked up at WSMR	Janus rebooted	31 mins		Trial stopped, then restarted at point of lockup; no PDUs lost
5	VSTARS crashed at Northrop Grumman	VSTARS rebooted	30 mins	7 hrs, 15 mins	Updates and coordination with Fort Hood interrupted; no PDUs lost
	Janus locked up at WSMR	Janus rebooted	23 mins		Trial stopped, then restarted at point of lockup; no PDUs lost

Extensive risk reduction testing was instrumental in preventing any major ADS system failures from affecting the Phase 2 test. Numerous ADS problems were identified and resolved during this risk reduction period, minimizing the amount of potential problems for the test. As a result, the ADS problems noted in Table 9 had minor impact on Phase 2 testing and caused only brief delays or reductions in capability.

4.2.2 JADS Objective 2-2. Assess the critical constraints and concerns in ADS support systems for T&E.

4.2.2.1 JADS Subobjective 2-2-1. Assess the critical constraints and concerns regarding ADS data management and analysis systems.

JADS Measure 2-2-1-1. Degree to which ADS nodes provide for collection, data entry, and quality checking of pre- and post-trial briefing data.

Quick-look analysis of results was used to support the post-trial briefings. This analysis relied primarily on automated data collection at all ETE Test nodes. The data collection tools included the JADS logger which collected the PDU log files and a Spectrum™ logger to monitor network performance. Data collection tools were attached to the network at each node without any impact on network or node performance. At the end of each test day, the data were remotely retrieved by the TCAC and the file size checked. This procedure supported timely quick-look analysis and test feedback.

In addition to electronic data logs, manually written logs were kept at each test site and used to support post-trial briefings. During the test rehearsals for Phase 2, log sheets were faxed to the TCAC at the end of each test day. This procedure proved less than effective, and a daily after-action teleconference call was added. This enabled the test controller to discuss and fully understand the problems of the day without having to review local log sheets.

JADS Measure 2-2-1-2. Adequacy of relevant test data storage at ADS nodes.

The ETE Test analysis requirements drove test data storage needs. The focus of data analysis at each site was on network latency, as well as the actual PDU input or data output at each site. The need to record PDU traffic at each node required a determination of the data output and reception rates at all sites. The largest contributor to ESPDU traffic was the output of the Janus simulation. ESPDUs from Janus are a function of the Janus heartbeat and the vignette design. During the Phase 2 testing, the Janus heartbeat was set to update all entities every eleven minutes during the first hour. In addition, Janus had to output an ESPDU when an entity changed state, i.e., start, stop, turn, etc. As a result, the ESPDU output grew as the number of movers increased. The ETE Test used five different vignettes, ranging from prehostility with low numbers of movers to an active battle vignette with more than 3,000 entities moving at one time. Prior to Phase 2 testing, the five vignettes were played and the ESPDU output recorded. The maximum file size seen during this testing was about fifteen megabytes. To support the data recording as well as file storage and local software requirements, the JADS Network and Engineering team installed 4-gigabyte hard drives on the SGI Indy at each node.

During preparations for the Phase 2 test, the Northrop Grumman node required the largest data capacity in order to support VSTARS software testing in a stand-alone mode. This testing required the playback of PDU files recorded from TRAC-WSMR to VSTARS. All five vignettes were played back at various times, and at least five vignette PDU files were stored on the SGI

Indy at all times. During actual Phase 2 testing, the ETE Test team found hard drive data storage capacity to be more than adequate.

The development of data storage needs required a full understanding of each node's requirements. Since the cost of hard drive storage has decreased dramatically over the past few years, it was cost effective to allow for unexpected growth by significantly exceeding the expected storage requirements.

JADS Measure 2-2-1-4. Ease with which data can be retrieved post trial from a given node.

During Phase 2 of the ETE Test, automated data were collected using PDU loggers at the nodes, and operational data were collected using log sheets at each node. The automated data collected during the test were retrieved from the JADS test locations by the TCAC using FTP, while JADS personnel transported the log sheets to JADS. The automated data were compressed and converted for analysis using JADS UNIX®-based tools.

The automated data retrieval process was very effective. For the ETE Test Phase 2, the automated data retrieval process needed about thirty minutes despite the large sizes of the log files being converted. Also, there were no problems encountered during any of the retrieval efforts. As exemplified by the ETE Test team's data retrieval process, any ADS data retrieval methodology need not be complex.

4.2.2.2 JADS Subobjective 2-2-2. Assess the critical constraints and concerns regarding configuration management of ADS test assets.

JADS Measure 2-2-2-1. Degree to which test managers can control the configurations of ADS participants, the ADS environment data, and ADS networks.

This measure determined if the test manager could adequately control the test configuration of ADS participants, the ADS environment data, and the ADS network both during and between test events. The JADS analysts conducted interviews with the test team members involved in configuration management on the Phase 2 test. The JADS analysts also monitored the progress of test and network configuration from formal integrated product team (IPT) and requirements meetings.

Configuration control for the ETE Test synthetic environment proved to be a challenge. The distributed nature of the test made configuration control more complex because of the many different organizations involved in the test. Unlike a single-site test effort, the ETE Test involved more than half a dozen organizations and two branches of the military. The added difficulty of the distributed network made frequent technical meetings and formal IPTs a must. These meetings provided the test manager with the ability to track progress and problems with the network configuration and data formats. These meetings also provided the forum for the system experts to resolve the issues with all those who were affected.

This process proved to be effective in controlling the Phase 2 configuration during the test build-up and preparation phase. In addition, there were no configuration control problems during the OT exectution.

Configuration control of an ADS test can add significant management issues when compared to non-ADS efforts. This added complexity requires a higher level of involvement by the test manager, as well as more frequent face-to-face meetings among technical personnel from the various ADS test nodes. An ADS test manager's job would be eased with the aid of an integration engineer.

4.2.3 JADS Objective 2-3. Develop and assess methodologies associated with ADS for T&E.

4.2.3.1 JADS Subobjective 2-3-2. Develop and assess methodologies associated with test execution and control for tests using ADS.

JADS Measure 2-3-2-3. Degree to which protocols, processes, and procedures are needed to enable effective centralized test control.

This measure determined the degree to which protocols, processes, and procedures were needed to enable effective centralized test control in a distributed environment. JADS personnel analyzed test logs, test team discussions, and after-action reports to determine how well the test control procedures worked and how they could be improved.

The test control procedures used during the Phase 2 test were developed and refined during the functionality and integration and risk reduction tests. These procedures included standardized checklists addressing the start-up and shutdown of the ETE Test network and the conduct of each test trial. The network checklist included procedures to verify network connectivity, data storage space, and time server accuracy and to test network transmission prior to test start. The test conduct checklist included detailed start-up procedures for each test node. These checklists are provided in Appendix A to this report.

Communication procedures were also developed during the FI and risk reduction tests. Based on the experience gained during these tests, the Phase 2 testers were able to use the conference phone lines to effectively resolve system failures and to facilitate useful discussions of the after-action reports.

Effective centralized test control was exercised through the test controller located at the TCAC. The test controller was responsible for starting and stopping each trial, monitoring the status of all nodes and network links, and declaring holds and restarts when necessary. The test controller was able to continuously monitor the status of the trials through a combination of network monitors in the TCAC and voice communications with key personnel at each site. These procedures proved effective for timely detection and resolution of system/network failures.

Test control in a distributed computing environment offers many challenges not experienced in conventional testing. The designers of a test network should carefully plan for test control, noting that good communication is required among all network nodes. Otherwise, poor test control can result in inaccurate and untimely information being disseminated throughout the test architecture and can waste valuable test time and test assets.

5.0 Lessons Learned

5.1 Technical Lessons Learned

5.1.1 Simulations

Simulations when used in ADS testing should be carefully planned and developed. The ADS tester must also be in close communication with each organization modifying simulations crucial to the test. The ETE Test Phase 2 succeeded because of the relatively high degree of reliability of the simulations used in the test. If simulation execution problems had occurred, the ETE Test team had arranged for a quick response by the personnel needed to fix those difficulties.

5.1.2 Interfaces

Distributed testing often requires linkage among dissimilar facilities, network equipment, and simulations. However, careful planning can significantly reduce the potential for difficulties arising from network interface problems. As part of their planning, the ETE Test team bought standard network equipment for all of the sites. Thus, the configuration of the ETE Test environment did not pose any problems during the Phase 2 test.

5.1.3 Networks

- Time sources must be synchronized. Time must be synchronized from the same time source, then validated at each network node to ensure that accurate, synchronized time is recorded at each node. The time server used in the ETE Test worked very well, ensuring that all loggers were set at the same time and keeping time differences between loggers to a minimum. Having the same time at all loggers helped speed up the analysis and allowed for the use of automated analysis tools.

  Data collection methods should be built into the simulation. The ETE Test environment failed to take data collection to the next level. Loggers with time stamping were used to record PDUs as they were going in and out of simulations. However, data collected from within the simulations were not time stamped or synchronized with the logger data. This presented considerable problems with the data analysis of the entire C4ISR system. Much of this analysis was done by hand or accomplished separately from the JADS logger data.

5.1.4 Instrumentation

- Special equipment was necessary for ADS network check-out and verification. Special test equipment and networking tools will rapidly isolate the specific cause of network and ADS/DIS problems. Without the special equipment, troubleshooting would have been accomplished by trial and error increasing time, cost, and personnel. In addition, the key

Network and Engineering personnel should be trained in the use of the special test equipment and networking tools.

- The flow and transfer of PDUs were critical to the ETE Test. PDU traffic was continuously monitored at all nodes to ensure that PDUs were constantly flowing. Since the ETE Test manning levels were insufficient to enable watching these monitors at all time, problems that interrupted PDU flow were not always immediately noticed. Some type of audio warning device might have reduced test time loss from a few minutes to seconds.

5.2 Infrastructure and Process Lessons Learned

5.2.1 Procedures

5.2.1.1 Planning

- The requirements for an ADS test must be clearly defined early in the test planning phase. Detailed planning and coordination are required to ensure a common understanding of all requirements, procedures, and test objectives since individual facilities are generally unfamiliar with conducting coordinated, distributed T&E tests.

- Flexibility in planning is essential. When doing something that has never been done before, preconceived notions of how the test should be executed will have to change as more is learned. Be open to new ideas, as some of the old ideas from the early stages of an ADS test program may become very expensive to bring to fruition. The ETE Test Phase 2 was originally slated to have nine scenarios. As the requirements for each scenario increased, their development costs also grew. These added costs eventually led to the deletion of the last four scenarios.

- Plan for the unexpected. Halfway through the ETE Test Phase 2 one of the key T-1 lines was inadvertently disconnected. This delayed the test by two days during the most critical portion of the test while technicians restored the lines. Travel plans had to be changed and budgets were strained. If possible, plan extra days on the end of a test period that can be eliminated if all goes well. It is much easier to return early than to stay longer.

- Minimize the impact of hardware problems. When using a complicated ADS network with a vast array of equipment, hardware problems will occur. Plan in such a way that unexpected hardware problems do not completely disrupt the test. During the ETE Test Phase 2, steps were taken to ensure that hardware problems did not disrupt the test for long periods of time. For example, data saves were accomplished frequently. In addition, the network was constantly monitored to ensure that hardware problems were fixed as soon as possible.

5.2.1.2 Development

- Use a stepping stone approach to testing where each successive ADS test builds on the success of earlier tests. This "test, analyze, fix, test" approach, in concert with structured, independent testing of the network, will greatly improve the chances for successful ADS testing.

- Risk reduction testing prior to actual test execution will help test team personnel identify and resolve potential ADS system problems.

- Understand communication requirements. Because of some changes in the test, voice communication requirements between the Fort Hood node and the White Sands node were dramatically increased. The only way for those nodes to communicate was through the direct line to the TCAC. This tied up the direct line for extended periods of time. For the next test, another connection will be added for direct communications between Fort Hood and White Sands.

5.2.1.3 Execution

- Briefings are needed before and after each ADS test. These briefings should include such information as the test objectives, telephone numbers to use for test control, the test configuration of each facility, instrumentation and data collection requirements, go/no go criteria, contingency and backup plans, and test conduct. A briefing checklist should be developed and used.

- Test control procedures should be well rehearsed. When many people are communicating on one phone line, a response order should be established and strictly followed to save valuable test time.

- Take advantage of the opportunities provided by ADS technology. At the beginning of Phase 2, the ETE Test team intended to log all operator actions in the LGSM. As the test progressed, the JADS analysts realized their efforts to obtain data from the LGSM operators would hamper their activities. Making use of the increase in test time provided by the ADS environment, the JADS analysts were able to automate most of their LGSM data collection activities and reduce the impact on the LGSM operators.

5.2.1.4 Evaluation

- Effective data management is needed. Linked facilities can generate a large volume of data at distributed locations. Without careful planning, key data may not be collected and/or transmitted to the analysis center, and data collected at the network nodes may not be in a useful form for centralized analysis. Before ADS testing, a comprehensive data management

plan must clearly identify the data to be collected at each network node, onsite processing of the data, and the data to be transmitted to the analysis center.

- Pretest rehearsals are also useful for improving evaluation procedures. The ETE Test team improved its data collection and analysis processes as a result of experiences from the functionality and integration and risk reduction tests.

5.2.1.5 Command and Control

- Have test controllers who are extremely familiar with the test and network configuration. The Phase 2 test succeeded partly because it had an experienced test controller with the necessary tools to evaluate problems and the authority to make meaningful decisions regarding test problems.

- Have a centralized test control center. The JADS TCAC is configured to allow for convenient, instant communications with all the nodes. It acted as the central point of contact between the nodes and for all problems. The test controller kept track of test progress and documented any problems that occurred.

- Establish control over resources. Linking various facilities using ADS can require significant development of facility interface hardware and software. A well-organized approach by experienced personnel enabled the ETE Test team to surmount problems encountered at Fort Hood, the most complicated node in terms of getting all necessary hardware established and connected before the Phase 2 test.

- Distributed tests require personnel distribution. When many distributed nodes are required for the successful completion of a test, personnel will need to be located at these nodes. The complexity and input an individual node contributes should guide the assignment of personnel. The ETE Test Phase 2 required several people at the Fort Hood, Northrop Grumman and TCAC nodes; only one person was needed at the White Sands node. The Fort Sill node used only resident personnel.

5.2.2 Policy

- Network management and troubleshooting must be disciplined and organized with a thorough understanding and strong configuration control of the ADS network. This approach enabled the ETE Test Phase 2 team to quickly recover from initial pretest network difficulties and to go on and achieve five days of successful execution and data collection.

- Flexibility is also needed. When one of the ETE Test network's T-1 lines was disconnected, JADS personnel were able to quickly develop and implement a contingency plan. Upon restoration of the T-1 line, the network was soon returned to its original configuration and the test continued.

5.2.3 Personnel

- Personnel involved in a distributed test should understand the "big picture." When people are geographically separated, it becomes easy for them to focus on their own individual portion of the test. When problems arise, personnel who understand the entire test and the overall network will find solutions much faster.

6.0 Conclusions/Recommendations

6.1 Utility

6.1.1 Utility Conclusions

6.1.1.1. Enhanced Testing. An ADS environment can enhance the testing of C4ISR systems.

- The Phase 2 test showed that ADS technology can realistically represent a C4ISR system enabling the system's users to collect valid and useful operational information.

- Compared to conventional methods, an ADS environment can realistically test C4ISR systems:

  - in larger battlespaces. It's possible to connect several Janus simulations together in order to multiply the simulated battlespace.

  - with larger numbers of ground-based entities at a much lower cost.

  - with more control over the specific aspects of the scenarios being tested. Using ADS, the test director is not at the mercy of a training exercise over which he/she has no direction. Rather, the test director can control the simulated entities.

  - for longer periods of time enabling increased data collection and the ability to analyze and improve the data gathering process.

  - under realistic but unsafe conditions, such as convoy vehicles driving across rugged terrain under wartime conditions.

- By allowing the simulation of large battlespaces with large numbers of entities, ADS technology provides testers with greatly expanded capabilities for test concept and design.

- Testers can use ADS to save time, resources and test personnel man-hours by linking several pieces of equipment and/or facilities together for simultaneous testing instead of conducting individual tests at different locations.

- ADS technology provides access to elements participating in the test from their normal work locations, greatly reducing the additional operational tempo required to support both testing and test integration, training and rehearsal.

6.1.1.2 DT&E Utility. The Phase 2 ADS architecture can allow the use of VSTARS for developmental testing of the JSTARS subsystems, other than the radar subsystems, including software. A ground-based ADS environment offers several benefits for DT&E.

- Multiple repetitions of the same scenario can be performed without competing for scarce test aircraft and range resources.

- The use of ground-based simulations and hardware offers the potential for enormous cost savings, as compared to a live test with the aircraft.

- Any conceivable test case can be "flown" in the laboratory without worrying about safety or limited assets provided the appropriate scenario generator is available.

- Bad software can be quickly discarded and new software could be tried the next day.

- Most importantly, when a live test is flown, as it must be, the testers can be reasonably sure that they will get the maximum value from the flight and test conditions.

6.1.1.3 Improved Opportunities for Training. If an ADS environment is developed for testing, the same environment can easily be modified and transitioned to the training world. ADS technology can then improve opportunities for training with a C4ISR system.

- Conventional training can be limited by the availability of those assets making up the C4ISR system's operational environment. ADS technology, by simulating those key assets, can provide longer periods of time for realistic operation of the C4ISR system.

- C4ISR system operators can take advantage of the additional training time provided by ADS technology to confirm current tactics and to test "what if" scenarios and new tactics.

- A C4ISR simulation incorporated into an ADS environment can enhance operator training by providing useful information on the battlefield surveillance and the targeting process. It can also help the battle manager by providing a high-level picture of the entire battlefield and aiding in the effective allocation of battle resources.

- An ADS environment can provide C4ISR system operators with the opportunity to check the interoperability and compatibility of their equipment.

- ADS simulations can help C4ISR system operators familiarize themselves with the maneuver tactics of foreign armed forces – valuable experience for possible future deployments.

- C4ISR system operators can train in an operational environment with multiple assets using the capabilities of ADS technology to tie several pieces of equipment and/or facilities together and to simulate large numbers of fielded vehicles and associated personnel. In contrast,

conventional training would provide far fewer assets in the operational environment, if any at all.

6.1.2 Utility Recommendations

- Large exercises could use the ETE Test environment to virtually augment the battlefield with simulated targets. During Phase 4, this capability will be demonstrated with the integration of a live E-8C Joint STARS aircraft into the ETE Test ADS environment.

- An ADS environment, like the ETE Test environment, is flexible enough to allow for further expansion and increased opportunities for testing C4ISR systems. The Janus battlespace can be expanded as required. Increasing the number of LGSMs or CGSs would create more realistic targeting capabilities. By adding other assets to the environment, such as an unmanned aerial vehicle (UAV) or a tactical aircraft simulator, the robustness of the environment could be significantly enhanced.

6.2 Technical

6.2.1 Technical Conclusions

- The ETE Test Phase 2 required only a small portion of the available bandwidth. This indicates that a much higher packet rate could be applied to ADS testing without causing bandwidth problems. The available bandwidth could have been used to facilitate a higher heartbeat by sending more frequent updates of entity state PDUs from Janus. During most of the Phase 2 test, a 15-minute heartbeat was used during the first hour, followed by a low rate of change-of-state PDUs after the first hour. During the last day of testing, the change-of-state PDU rate was dramatically increased. The future ETE Test phases will incorporate the higher PDU rate to take advantage of the available bandwidth.

- The ETE Test network was highly reliable and stable during the Phase 2 test following the fix of the T-1 problems experienced on 28 and 29 September.

- The ETE Test team's extensive risk reduction testing played an important role in eliminating the presence of major ADS system failures during Phase 2 testing. Many ADS problems were identified and resolved during this risk reduction period, thus minimizing their potential for affecting the actual testing. As a result, the ADS problems noted in Table 9 had only a minor impact on Phase 2 testing and caused only brief delays or reductions in capability.

6.2.2 Technical Recommendations

- With careful planning and resource management, testers can address the issues associated with integrating simulations into an ADS test environment.

- Identify the assumptions and limitations associated with those simulations.

- Budget, schedule, and provide the manpower necessary to develop the simulations. Simulation development is typically labor intensive and thus costly.

- Determine the level of simulation detail needed for the ADS test. Development costs are directly related to the level of simulation detail.

- Identify and provide training for the users of the simulations.

6.3 Infrastructure

6.3.1 Infrastructure Conclusions

- ADS can reduce the number of troops and associated equipment involved in tests because of its simulation of fielded forces. However, the ADS infrastructure requires technical personnel to set up and execute the tests and to analyze the test results.

- Highly structured test control is a key ingredient for ADS test success. This test control should include formalized procedures with an emphasis on checklists.

- An ADS test can't always count on having the personnel requirements for a distant node supplied by an organization local to the node. Even if an ADS test is able to employ these people, it may then lose them to other activities deemed more important by the local organization.

- An ADS environment necessitates sophisticated instrumentation with rigorous processing speed, data storage, and data integration capabilities. This instrumentation can be costly and can require trained personnel for its successful operation.

- Distributed testing typically means distributed personnel and distributed equipment. Distributed personnel lead to high travel costs. Equipment located at distant network nodes will still require maintenance either through contracts or trips by a network engineering team.

- ADS analysts must have a well-planned and organized approach to managing the large amounts of data produced from ADS testing.

6.3.2 Infrastructure Recommendations

- Make every effort to simplify the infrastructure. Time spent in the planning stages of an ADS test, with an emphasis on reducing the complexity of the test network, is time well spent. Use proven hardware and keep it the same wherever possible.

- Keep in mind the disadvantages, as well as benefits, of the networked nature of an ADS environment. The ADS tester will almost always be dependent upon a telecommunications provider. For example, the ETE Test environment was degraded for two days because of the inadvertent termination of a T-1 line.

APPENDIX A -- Test Procedures

A1.0 Test Procedures

Various types of checklists were used during the execution of the Phase 2 test. The Test Control and Analysis Center (TCAC) test controller checklist can be found in Section A1.1, *TCAC Test Procedures*. This checklist was used to ensure network and logger functionality and to provide overall test control procedures. Each node (White Sands Missile Range [WSMR], Northrop Grumman, and Fort Sill) incorporated the logger functions from the TCAC checklist into their own checklist.

Other checklists were used to direct the operation of various pieces of test equipment. An example is included in Section A1.2, *TCAC Plan View Display (PVD) Procedures*.

Section A1.3, *WSMR Procedures* is representative of the site-specific checklists. WSMR, Northrop Grumman and Fort Sill all developed procedures for operation of the End-to-End (ETE) Test environment equipment. Only Fort Hood, the only site without a logger, failed to develop written procedures. Their procedures were primarily accomplished by the resident specialists who have their own procedures.

A1.1 TCAC Test Procedures

The following are the written test procedures used in the TCAC during Phase 2 testing.

72 HOURS PRIOR TO TEST

Network Coordinator: ____________________

Date: __________ Test Time: __________ to __________

1. ________ Check supplies.

2. Turn on equipment.
   ________ a. Turn on 3 Barcos (Spectrum [Sun5] on 1, Janus [hp735] on 2, and NetVis [indigo2] on 3).
   b. Log in as "root" to **indigo2** in the TCAC, and **indy4** in communications room 1.
   ________ 1) From the toolchest, select Toolbox, JADS Toolbox, Monitor, PDU Monitor, PDU Statistics, Show Stats to display protocol data units (PDUs).
   ________ 2) From the toolchest, select NetVis, NetGraph-ETE to display network traffic.
   ________ 3) From the toolchest, select NetTests, Status Check ETE to start and display network connectivity tests. (**uts** in comm rm 1 pings **wsmr, ftsill**, and **fthoodafatads**. **indigo2**, pings, **grumman**, **indy3**, and **sparc5** at Ft Hood).
   ________ c. In the TCAC, run Spectrum on the **Sun20** (server) and **Sun5** (graph) to display Zulu time and router status.
   ________ d. Create an empty file "`touch /scripts/.go`" in grumman, indigo2, and indy4.

3. ________ Clear router interfaces. To clear the **grumman_router**, **jads_router**, and **fthood_router** from **indigo2**; and **fthood_router**, **ftsill_router**, and **wsmr_router** from indy4, run: "`/scripts/clear_router ete.`"

4. ________ Not used.

5. Time accuracy. Verify that each site has network time protocol **(NTP)** running.
   ________ a. From **uts**, run "`/scripts/check_time`" and verify that the offsets for **ftsill** and **wsmr** are less than 1 millisecond (ms).
   ________ b. From **indigo2**, rlogin to **indy1**, run "`/scripts/check_time.`" Verify offsets for **grumman**, **indy3**, and **sparc5** are less than 1 ms.

6. Available disk space. Verify that each logger has at least **600 megabytes (MB)** of unused disk space available on the **/disk2** partition.
   ________ a. From **uts**, rlogin to **ftsill** and **wsmr**, in turn, and from **indigo2**, rlogin to **grumman**, and **indy3**, in turn.
   ________ b. Run "`df -k`" on each machine (including **uts**) to display the available disk space. Verify that each has at least **600 MB** available.

7. Port settings. Verify that each logger is set to port **3000** and the exercise identification (ID) is **0**.
   ________ a. From **uts**, rlogin to **ftsill** and **wsmr**, in turn, and from **indigo2**, rlogin to **grumman**, and **indy3**, in turn.
   ________ b. Run "`more /scripts/dt_logger`" to view the file. Look for the entry: "`/usr/local/bin/jads_logger 3000 0 /disk2/logfiles /$testdate"_test"$testnum"_"$runnum"_"$site".log"` " entry in two places.

8. ________ Voice conference net. Verify the net is functional by dialing in from two different phones in the TCAC at the same time to establish the net.

9. ________ Not used.

10. Data collection test a:
   ________ a. From **uts**, rlogin to **ftsill** and **wsmr**, simultaneously, and from **indigo2**, rlogin to **grumman**, and **indy3**, simultaneously.
   ________ b. Start the **ftsill**, **grumman**, **indy3**,and **uts** loggers using test number "`000`" and run number "`a`" (i.e. - "`/scripts/dt_logger 000 a`").
   ________ c. Run the "`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`" file on the **wsmr** machine.
   ________ d. Determine when run is complete. Stop all loggers ("`Ctrl-C`").
   ________ e. Check digital communications terminal (DCT) results. Verify reception of **2281** PDUs on **grumman**, **indy3**, and **uts** (or **indy4**) loggers. (No PDUs at **ftsill**).

11. Data collection test b:
   ________ a. From **uts**, rlogin to **ftsill** and **wsmr**, simultaneously, and from **indigo2**, rlogin to **grumman**, and **indy3**, simultaneously.
   ____

b. Start the **grumman**, **indy3**, **uts** and **wsmr** loggers using test number "`000`" and run number
________ "`a`" (i.e. - "`/scripts/dt_logger 000 a`").

c. Run the "`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`"
________ file on the **ftsill** machine.

________ d. Determine when run is complete. Stop all loggers ("`Ctrl-C`").

e. Check DCT results. Verify reception of **2281** PDUs on **grumman**, **indy3**, and **uts** loggers.

12. ________ Report the results of the network checks to the test controller. Supervise repairs as necessary to prepare equipment for the test sequence.

PRETEST (DAY OF TEST)

Network Coordinator: ____________________

Date: __________ Test Time: __________ to __________

1. ________ Check supplies. Provide checklists, blank log sheets, file name lists, pens, pencils, scratch paper, and 4 millimeter (mm) tape cartridges for the test.

2. Turn on equipment.
   - ________ a. Turn on 3 Barcos (Spectrum [Sun5] on 1, Janus [hp735] on 2, and NetVis [indigo2] on 3).
   - b. Log in as "root" to **indigo2** in the TCAC, and **indy4** in communications room 1.
     - ________ 1) From the toolchest, select Toolbox, JADS Toolbox, Monitor, PDU Monitor, PDU Statistics, Show Stats to display PDUs.
     - ________ 2) From the toolchest, select NetVis, NetGraph-ETE to display network traffic.
     - ________ 3) From the toolchest, select NetTests, Status Check ETE to start and display network connectivity tests. (**uts** in Comm Rm 1 pings **wsmr, ftsill**, and **fthoodafatads**. **indigo2**, pings, **grumman**, **indy3**, and **sparc5** at Ft Hood).
   - ________ c. In the TCAC, run Spectrum on the **Sun20** (server) and **Sun5** (graph) to display Zulu time and router status.

3. Clear router interfaces. To clear the **grumman_router**, **jads_router**, and **fthood_router** from **indigo2**; and **fthood_router**, **ftsill_router**, and **wsmr_router** from indy4, run:
________ "`/scripts/clear_router ete.`"

4. ________ Not used.

5. Time accuracy. Verify that each site has **NTP** running.
   - ________ a. From **uts**, run "`/scripts/check_time`" and verify that the offsets for **ftsill** and **wsmr** are less than 1 ms.
   - ________ b. From **indigo2**, rlogin to **indy1**, run "`/scripts/check_time.`" Verify offsets for **grumman**, **indy3**, and **sparc5** are less than 1 ms.

6. ________ Available disk space. Performed at each logger by the logger operator.

7. _________ Port settings. Performed at each logger by the logger operator.

8. _________ Join the voice conference net. Both the test controller and the network coordinator (NC) dial **61143** in the TCAC to establish the conference net.

9. _________ Time synchronization. **ftsill**, **grumman**, **indy3**, and **wsmr** operators check global positioning system (GPS) time reception by typing "`date`" and press **Enter** on the NC's mark. Report time to NC.
(NOTE: **indy1** is time server for classified, **uts** is time server for unclassified.)

10. Data collection test a:
_________ a. Cue **ftsill**, **grumman**, **indy3**,and **uts** operators to start loggers using test number "`000`" and run number "`a`" (i.e. - "`/scripts/dt_logger 000 a`").
_________ b. Cue **wsmr** Operator to run "`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`" file.
_________ c. Determine when run is complete. Cue all operators to stop loggers ("`Ctrl-C`").
_________ d. Check DCT results - Have **grumman**, **indy3**, and **uts** operators verify reception of **2281** PDUs. (No PDUs at **ftsill**).

11. Data collection test b:
_________ a. Cue **grumman**, **indy3**, **uts**, and **wsmr** operators to start loggers using test number "`000`" and run number "`b`" (i.e. - "`/scripts/dt_logger 000 b`").
_________ b. Cue **ftsill** operator to run "`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`" file.
_________ c. Determine when run is complete. Cue all operators to stop loggers ("`Ctrl-C`").
_________ d. Check DCT results - Have **grumman**, **indy3**, **uts**, and **wsmr** operators verify reception of **2281** PDUs. (No PDUs at **ftsill**).

12. _________ Report the results of the network checks (items 9-11) to the test controller.

The pretest phase is now complete. Proceed to the test run phase.

NOTE: Sometimes the logger process does not terminate on the **grumman** logger. In that case, run `/scripts/find_logger` on the **grumman** logger to kill the process and delete the old logfile before restarting the logger with the same filename.

TEST RUN

Network Coordinator: ______________________

Date: ___________ Lab Time: ___________ to ___________

1. _________ Start loggers. Obtain the test and run numbers from the test controller and record on the log sheet. Operators are cued by the test controller when to start loggers. Record start time on the log sheet.
_________ a. Early in the test run, verify with operators that all loggers are receiving PDUs (number is

increasing.

_________ b. Periodically check with operators that all loggers continue to receive PDUs (number is increasing).

_________ c. Periodically check "bat" phone operation if not used regularly.

_________ d. Every ½ hour, run a time accuracy check. From **uts**, run "`/scripts/check_time`" to check **ftsill** and **wsmr**. From **indigo2**, rlogin to **indy1** and run "**/scripts/check_time**" to check `indy1`, **grumman**, and **tcacindy**. Time offsets should be **<1** ms.

_________ e. Keep written event log.

2. Stop loggers. Loggers stop recording data when directed by the test controller ("**Ctrl-C**").

_________ a. Record the stop time and the total number of PDUs from each logger on log sheet.

_________ b. Confirm that the required data have been logged. From **uts**, rlogin to **ftsill** and **wsmr** and run "`ls -l /disk2/logfiles.`" From **indigo2**, rlogin to **indy3**, and **grumman** and run "`ls -l /disk2/logfiles`." Check the file sizes; the filename is "***mmddyy_test#-run#_loggername*.log.**"

3. _________ Subsequent runs. When additional runs are required, repeat steps 1 and 2 for each run.

The test run phase is now complete. Proceed to the post-test phase.

POST TEST (DAY OF TEST).

Network Coordinator: ______________________

Date: ___________ Test Time: ___________ to ___________

1. Remote file capture. Consolidate, compress, and copy the test run logger files from each remote site.

_________ a. For classified data, rlogin to each logger (**grumman** and **indy3**), in turn, from **tcacindy** in the TCAC, or
For unclassified data, rlogin to each logger (**ftsill**, **wsmr**, and **uts**), in turn, from **uts**.

_________ b. If only 1 file for the day exists in the logger at a site, skip to step c. If more than 1 log file for the day exists at a site, consolidate them by using the command
"`tar cvf mmddyy_sitename.log.tar mmddyy*.log`"
where `*` is the wildcard character that includes all the files for that day for that site name. (e.g., - "`tar cvf 040798_wsmr.log.tar 040798*.log`").

_________ c. Compress the single log file (e.g., - "`compress 040798_wsmr.log`") or the tar file from step b ("`compress 040798_wsmr.tar`").

_________ d. On **tcacindy**, run "`/scripts/rcp_etefile`" to copy the tar'd and compressed classified files ("***mmddyy_sitename*.log.Z**") from both **grumman** and **indy3** loggers to **tcacindy:/disk2/ete/*mmddyy*/.**

_________ e. On **uts**, run "`/scripts/rcp_etefile`" to copy the tar'd and compressed unclassified files ("***mmddyy_sitename*.log.z**") from **ftsill**, **uts**, and **wsmr** loggers to
_________ **uts:/disk2/ete/*mmddyy*/**.

_________ f. Copy the unclassified files from step e to 4mm tape and activate the write protect feature.

g. Move the tape to **tcacindy** and copy the unclassified files from the tape to **/disk2/ete/*mmddyy*/**

(i.e., from the **ete** directory, run `tar xv` to extract the files from the tape to the hard drive). **Make sure the write protect feature is ON.**

2. <u>Backup tapes</u>.
   __________ a. Create a backup tape of the files in **tcacindy:/disk2/ete/*mmddyy*/** using either the " `tar cv mmddyy` " command while in the **ete** directory (or the tape tool on the **tcacindy** desktop).
   b. Verify the backup using either the "`tar tv`" command or the tape tool.
   __________ c. Remove the tape from the drive and label it.
   __________ d. Repeat a, b, and c to create a duplicate tape.
   __________ e. Deliver both tapes to the ETE Test team representative.

3. __________ <u>Delete</u> the data collection test and the backed-up log files from **/disk2/logfiles/** on all loggers.

4. __________ On the <u>last day of testing</u>, delete the file "`/scripts/.go`" in grumman, indigo2, and indy4.

5. __________ <u>Logoff</u> from logger. Turn **Off** the monitor, but leave the central processing unit (CPU) **On**!!!

6. __________ Participate in mission debrief, if applicable.

A1.2 TCAC Plan View Display (PVD) Procedures

The following procedures were used to initiate test monitoring with the Janus plan view display program. This is representative of the specific checklists developed to aid in the operation of test equipment.

Functionality/Integration Test Checklist
(TCAC-PVD)

Date: ____________________________
Scenario: ____________________________

Test Start Time (z): ______________ Test Stop Time (z): ______________
Scenario Start Time: ______________ Scenario Stop Time: ______________

Step #	POC	Action	Event	Go/No Go
Run PVD				
1	ETE	Power on the hp735 monitor. Log on to the hp735 as **hovey**.		
2	ETE	From the xterm window that appears, type *pvd*, and hit ***enter***.	Use this alias to start Janus plan view display.	

3	ETE	From the Janus plan view display menu, verify the parameters for the run: Workstation ***1*** Terrain File _____ Screen File _____ Symbol File ***3*** Symbol Size ***10*** Terrain File Meridian ***45*** Exercise ID ***BLANK*** Map Spheroid ***1*** Mode ***BLANK*** Terminate this Run ***N*** and hit ***keypad enter***.	Use the correct terrain file and screen file for the vignette.	
4	ETE	Wait until the PVD terrain and combat systems databases are loaded.	Last message: Opening file *../jads_ete/trn/TSCRN__.DAT*	
5	ETE	Double click the *Analyst_Workstation_WS1* icon to bring up the scenario window.		
6	ETE	From the *Analyst_Workstation_WS1* scenario window, functions menu, left click **Draw CAC**.		
7	ETE	From the *Analyst_Workstation_WS1* scenario window, CAC File menu, select the CAC file number to display. Left click increases number, and right click decreases number. Left click **Add** to display the CAC.	Places command and control overlays on the scenario box.	
8	ETE	From the *Analyst_Workstation_WS1* scenario window, function menu, left click **Display**.	Ready to receive and display DIS PDUs.	

9	ETE	From the *Analyst_Workstation_WS1* scenario window menu: Left click any **tick** on the zoom in/out menu, then select the desired zoom point on the scenario box. Left click **CAC**. Left click **Display**. Left click **Clear**.	Used as necessary to zoom in/out of the scenario box. Used as necessary to add or remove the command and control overlays which have been added in step 7. Used as necessary to start or stop Janus plan view display from receiving PDUs. Used as necessary to clear any text or information displayed on the scenario box. NOTE: A particular function is active when highlighted.	

Step #	POC	Action	Event	Go/No Go
Stop PVD				
1	ETE	From the *Analyst_Workstation_WS1* scenario window, right click **End**.	Shuts down PVD.	
2	ETE	Minimize the *Analyst_Workstation_WS1* scenario window.	In the xterm that remains, verify this message: STOP -----JANPVD Program Terminated-----	
3	ETE	From the *Analyst_Workstation_WS1* icon, right click and choose close.	Closes the scenario window.	

Step #	POC	Action	Event	Go/No Go
Shut Down Test				
1	ETE	Left click **EXIT** from the HP VUE front panel.	Signs off the hp735.	
2	ETE	Left click *Continue logout* from the dialog box.	Confirms desire to log out.	
3	ETE	Power off the hp735 monitor.		

A1.3 WSMR Procedures

This checklist is representative of the individual site checklists. It incorporates the logger functionality and the site specific actions required by the operator(s). These are maintained by the site specialists and updated as changes are required.

Functionality/Integration Test Checklist (WSMR)

Date: ____________________
Scenario: ____________________
Janus File: ____________________
Indy File: ____________________

Test Start Time (z): ____________ Test Stop Time (z): ____________
Scenario Start Time: ____________ Scenario Stop Time: ____________

Step #	POC	Action	Event	Go/No Go
Network Activation				
1	ETE and N&E	Verify operation of hotlink phone. If no go, contact N&E to fix the network.	Enables secure and unclassified voice communications.	
2	ETE and WSMR	Verify that WSMR indy and the WSMR hp715 are on the JADS ETE network.	Initial step in ensuring network is operational.	
3	N&E	Verity N&E has cleared and reset routers.	Clears router interface cards.	
4	ETE	Power on the WSMR monitor. Log on to WSMR as **dislog**.	Restarts the indy.	

		From a Unix shell window as **su**, run */scripts/restart.*		
5	ETE	After a successful restart, log on to wsmr as **dislog**.	Signon is used for checking network communications and logging PDU data.	
6	ETE	From a Unix shell window as **su**, run */scripts/ping_test* to get ping statistics for each remote site.	Verifies that each network link is operational. 3% loss at Fort Sill and uts is normal.	

7	ETE	From a Unix shell window as **su**, run */scripts/check_time.*	Displays the offset from uts. Should be less than 1 ms.	
8	ETE	From a Unix shell window as **su** and at the test controller's direction, run */scripts/run_player 3000 /disk2/logfiles/ne_test.log* to check ability to send PDUs to each remote site.	Verifies sending 2281 PDUs and receiving the same number of PDUs at each remote site.	
9	ETE	From a Unix shell window as **su** and at the test controller's direction, run */scripts/dt_logger* _____ _____ to check ability to receive PDUs from a remote site. At the test controller's direction, hit **Ctrl-C** to end the logfile.	Verifies receiving 2281 PDUs from a remote site.	
10	ETE	From a Unix shell window, *cd /usr/local/bin* and run *./display_pdu_rate.* Select port ***3000 0.*** Left click ***start.***	Verifies that PDU_rate = 0. Ensures that there aren't any DIS communications before the start of testing.	

Step #	POC	Action	Event	Go/No Go
Start WSMR Logger				
1	ETE	From a Unix shell window as **su** on WSMR, run */scripts/dt_logger* ______ ______	Script that runs the JADS logger.	
2	ETE	Verify the logfile name as */disk2/logfiles/____________wsmr.log* and port 3000.	Opens port 3000 to listen and log all DIS communications. Writes to the listed logfile.	

Step #	POC	Action	Event	Go/No Go
Start Janus				
1	ETE	Power on the c180 monitor. Log on to the c180 as **JADS.**		
2	ETE	From an hpterm window, type ***janus.exe***, and hit ***enter***.	Use this executable to start Janus.	
3	ETE	Left click ***PE*** (Program Execution) from the Janus User Options menu.	Brings up the Program Execution menu.	
4	ETE	Left click ***JE*** (Janus Execution) from the Program Execution menu.	First step in defining the scenario.	
5	ETE	Type desired scenario number ______ for the run, and hit ***enter***. Type run number *1*, and hit ***enter***.	Tells Janus which scenario to run.	
6	ETE	Hit ***enter*** again to continue.	Ready to continue.	
7	ETE	Verify that ***1*** is entered. Hit ***enter*** one more time.	Use a normal run.	
8	ETE	From the Janus Runtime Screens menu, left click ***11***. Verify time of day is correct for the vignette, and hit ***keypad enter***.	Verifies time of day.	

9	ETE	From the Janus Runtime Screens menu, left click ***22***. Verify that there is a setup for: *WS Number 1*,and *Side 1*, and hit ***keypad enter***.	Verifies that a controller workstation has been configured.	
10	ETE	From the Janus Runtime Screens menu, left click ***66***. Verify the DIS operational parameters for the run: Janus side ***1*** DIS side ***2*** DIS COMM calls/sec _______ Units processed/COMM call _______ Terrain File Meridian (+E) ***45*** Heartbeat(s) _______ Dead Reckoning Threshold ***999*** Site ***TRAC-WSMR 23*** Host CPU ***HP 4*** Exercise ***JADS-ETE 4*** DIS version transmit ***4*** DIS version receive ***4*** and hit ***keypad enter***.	Verifies DIS parameters. Calculate the new heartbeat as follows: $C \times R \times H \leq T$ where C = calls/sec, R = units/call, H = heartbeat, and T = total number of units in scenario	
11	ETE	Left click ***JJ*** (Begin Janus) from the Janus Runtime Screens menu.	Loads the Janus scenario.	
12	ETE	Wait until the Janus scenario loads. Verify: Scenario number __________ Total number of units __________		
13	ETE	Double click the *side1* icon to bring up the scenario window.	This brings up the scenario window which allows a Janus operator to interact (game) the exercise.	

Step #	POC	Action	Event	Go/No Go
Run Scenario				
1	ETE	From the *side1* scenario window, left click ***DIS***.	DIS button highlights. Opens DIS communications.	
2	ETE	From the *side1* scenario window, left click ***START***.	First step in running a Janus scenario.	
3	ETE	Minimize the Janus scenario window (*side1*). Type ***rr*** in the Janus window, and hit ***enter***.	Ready to continue the Janus run.	
4	ETE	Type ***n*** and hit ***enter***.	No planned save.	
5	ETE	Hit ***enter*** again.	Default checkpoint frequency.	
6	ETE	Double click the Janus scenario window (*side1*).	Verifies scenario movements and a running time of day counter.	
7	ETE	Verify that loggers are logging.		

Step #	POC	Action	Event	Go/No Go
Stop Scenario				
1	ETE	From the *side1* scenario window, left click ***DIS***.	DIS button unhighlights. Closes DIS communications.	
2	ETE	From the *side1* scenario window, right click ***ADMIN***.	Brings up options menu.	
3	ETE	Left click ***EJ*** (End Janus).	Quits the scenario run.	
4	ETE	Right click 2 times.	Completely closes Janus.	
5	ETE	Left click EXIT from the HP VUE front panel.	Sign off the hp715.	

Step #	POC	Action	Event	Go/No Go
Shut Down Test				
1	ETE	Power off the c180 monitor, and shutdown CPU.		
2	ETE and N&E	Make sure that JADS N&E FTP */disk2/logfiles/___________wsmr.log* back to JADS and place the file in ***/usr/testdata2/logs/ete/DDMMYY***	Ensures data integrity. This file will be analyzed by JADS analysts.	
3	ETE	Power off the wsmr monitor.		
4	ALL	After-action review		

APPENDIX B
Joint STARS Multiservice Operational Test and Evaluation
Phase 2 Measures Correlation

February 1999

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Appendix B
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APPENDIX C -- Glossary

A

Accreditation. See: distributed simulation accreditation, model/simulation accreditation.

Accuracy. The degree of exactness of a model or simulation relative to an established standard with high accuracy implying low error. [DIS]

Activity. An event that consumes time and resources and whose performance is necessary for a system to move from one event to the next. [DIS]

Advanced Distributed Simulation (ADS). A set of disparate models or simulations operating in a common synthetic environment. The ADS may be composed of three modes of simulation: live, virtual and constructive, where the latter can be seamlessly integrated within a single exercise. **See also:** live simulation; virtual simulation; constructive simulation. [DIS]

Aggregate. An activity that combines individual entities into a singular entity. **Contrast with:** disaggregate. [DIS]

B

Battlespace. The three-dimensional battlefield. [DIS]

Benchmark. (v) The activity of comparing the results of a model or simulation with an accepted representation of the process being modeled. (n) The accepted representation of the modeled process. [DIS]

Bit. The smallest unit of information in the binary system of notation. [IEEE 1278.1]

Broadcast. A transmission mode in which a single message is sent to all network destinations, i.e., one-to-all. Broadcast is a special case of multicast. **Contrast with:** multicast; unicast. [IEEE 1278.2]

C

Compatible. Two or more simulations are DIS compatible if (1) they are DIS compliant, and (2) their models and data that send and interpret PDUs support the realization of a common operational environment among the systems (coherent in time and space). **Contrast with:** compliant, interoperable. [DIS]

Compliant. A simulation is DIS compliant if it can send or receive PDUs in accordance with IEEE Standard 1278 and 1278 (working drafts). A specific statement must be made regarding the qualifications of each PDU. **Contrast with:** compatible, interoperable. [DIS]

Conceptual Model. A description of the content and internal representations which are the user's and developer's combined concepts of the exercise. It includes logic and algorithms and explicitly recognizes assumptions and limitations. [DIS]

Constructive Simulation. Models and simulations that involve simulated people operating simulated systems. **See Also:** war games; higher order model (HOM). [DIS]

Continuous Model. (l) A mathematical or computational model whose output variables change in a continuous manner; that is, in changing from one value to another, a variable can take on

all intermediate values. For example, a model depicting the rate of air flow over an airplane wing. **Syn:** continuous-variable model. (2) A model of a system that behaves in a continuous manner. **Contrast with:** discrete model. [DIS]

Continuous Simulation. A simulation that uses a continuous model. [DIS]

Continuous-Variable Model. **See:** continuous model. [DIS]

Control Station. (1) A facility which provides the individual responsible for controlling the simulation and the capability to implement simulation control as protocol data units (PDUs) on the distributed interactive simulation (DIS) network.
Syn: simulation - management station. [DIS]

D

Data. Representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation or processing by humans or automatic means. [DIS]

Database. A collection of data organized according to a schema to serve one or more applications. [DIS]

Data Certification. The determination that data have been verified and validated. (1) Data producer certification is the determination by the data producer that data have been verified and validated against documented standards of criteria. (2) Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage. [DIS]

Data Logger. A device that accepts protocol data units (PDUs) from the network and stores them for later replay in the same time sequence as the PDUs were originally received. **See also:** protocol data unit (PDU). [IEEE 1278.3]

Data Validation. The documented assessment of data by subject area experts and comparison to known or best-estimate values. (1) Data producer validation is that documented assessment within stated criteria and assumptions. (2) Data user validation is that documented assessment of data as appropriate for use in an intended M&S. [DIS]

Data Verification. The use of techniques and procedures to ensure that data meet specified constraints defined by data standards and business rules. (1) Data producer verification is the use of techniques and procedures to ensure that data meet constraints defined by data standards and business rules derived from process and data modeling. (2) Data user verification is the use of techniques and procedures to ensure that data meet user specified constraints defined by data standards and business rules derived from process and data modeling and that data are transformed and formatted properly. [DIS]

Data Verification, Validation, and Certification. The process of verifying the internal consistency and correctness of data, validating that they represent real world entities appropriate for their intended purpose or an expected range of purposes, and certifying them as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives: producer and user process. **See:** data validation, data verification, and data certification. [DIS]

Dead Reckoning. **See:** remote entity approximation.

Deaggregate. **See:** disaggregate. [DIS]

Distributed Interactive Simulation (DIS). A synthetic environment within which humans may interact through simulation(s) at multiple sites networked using compliant architecture, protocols, standards, and databases (DoDD 5000.59P)

E

Electronic Battlefield. **See:** synthetic environment. [DIS]

Entity. Any component in a system that requires explicit representation in a model. Entities possess attributes denoting specific properties. **See:** simulation entity. [DIS]

Environment. (1) The texture or detail of the domain, such as cities, farmland, sea states, etc. (2) The external objects, conditions, and processes that influence the behavior of a system (such as terrain relief, weather, day, night, terrain cultural features, etc.) [DIS]

Event. (l) An occurrence that causes a change of state in a simulation. **See also:** conditional event; time-dependent event. (2) The instant in time at which a change in some variable occurs. [DIS]

Event-Driven Simulation. **See:** event-oriented simulation. [DIS]

Event-Oriented Simulation. A simulation in which attention is focused on the occurrence of events and the times at which those events occur; for example, a simulation of a digital circuit that focuses on the time of state transition. **Syn:** event-driven simulation; event-sequenced simulation. [DIS]

Event-Sequenced Simulation. **See:** event-oriented simulation. [DIS]

Exercise. (1) One or more sessions with a common objective and accreditation. (2) The total process of designing, assembling, testing, conducting, evaluating, and reporting on an activity. **See:** simulation exercise. **Syn:** experiment, demonstration. [DIS, IEEE 1278.3]

F

Fidelity. (1) The similarity, both physical and functional, between the simulation and that which it simulates. (2) A measure of the realism of a simulation. (3) The degree to which the representation within a simulation is similar to a real-world object, feature, or condition in a measurable or perceivable manner. **See also:** model/simulation validation. [DIS, IEEE 1278.1]

Field. (1) A series of contiguous bits, treated as an instance of a particular data type, that may be part of a higher level data structure. (2) An external operating area for actual vehicles or live entities. **See:** field instrumentation. [DIS, IEEE 1278.1]

G

Graphical Model. A symbolic model whose properties are expressed in diagrams. For example, a decision tree used to express a complex procedure. **Contrast with:** mathematical model; narrative model; software model; tabular model. [DIS]

Ground Truth. The actual facts of a situation without errors introduced by sensors or human perception and judgment. [DIS]

H

Human-in-the-Loop Model. See: interactive model.

Human-Machine Simulation. A simulation carried out by both human participants and computers, typically with the human participants asked to make decisions and a computer performing processing based on those decisions. [DIS]

I

Interactive Model. A model that requires human participation. **Syn:** human-in-the-loop model. [DIS]

Interoperable. Two or more simulations are DIS interoperable for a given exercise if they are DIS compliant, DIS compatible, and their performance characteristics support a fair fight to the fidelity required for the exercise. **Contrast with:** compatible, compliant. [DIS]

Interoperability. (1) The ability of a set of simulation entities to interact with an acceptable degree of fidelity. The acceptability of a model is determined by the user for the specific purpose of the exercise, test, or analysis. (2) The ability of a set of distributed interactive simulation applications to interact through the exchange of protocol data units. [DIS]

L

Live Entity. A perceptible object that can appear in the virtual battlespace but is unaware and non-responsive (either by intent, lack of capability or circumstance) to the actions of virtual entities. **See also:** field instrumentation. **Contrast with:** live instrumented entity. [DIS]

Live Instrumented Entity. A physical entity that is in the real world and can be represented in the distributed interactive simulation (DIS) virtual battlespace which can be manned or unmanned. The live instrumented entity has internal and/or external field instrumentation (FI) devices/systems to record and relay the entity's surroundings, behavior, and/or reaction to events. If the FI provides a two-way link, the events that affect the live instrumented entity can be occurring in the virtual battlespace as well as the real world. **See also:** field instrumentation, live entity. [DIS]

Local Area Network (LAN). A class of data network which provides high data rate interconnection between network nodes in close physical proximity. [IEEE 1278.3]

M

Measure of Performance (MOP). Measure of how the system/individual performs its functions in a given environment (e.g., number of targets detected, reaction time, number of targets nominated, susceptibility of deception, task completion time). It is closely related to inherent parameters (physical and structural) but measures attributes of system behavior. **See also:** measures of effectiveness (MOE). [IEE 1278.3]

Model. (l) An approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system. Note: Models may have other models as components. (2) To serve as a model as in (1). (3) To develop or use a model as in (1). (4) A mathematical or otherwise logical representation of a system or a system's behavior over time. [DIS]

Model/Simulation Accreditation. The official certification that a model or simulation is acceptable for use for a specific purpose. **See also:** distributed simulation accreditation. **Contrast with:** model/simulation validation, model/simulation verification. [DoDD 5000.59]

Model/Simulation Validation. The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended use(s) of the model. **See also:** distributed simulation validation, fidelity. **Contrast with:** model simulation accreditation, model simulation verification. [DoDD 5000.59]

Model/Simulation Verification. The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. **See also:** distributed simulation verification. **Contrast with:** model simulation accreditation, model simulation validation. [DoDD 5000.59]

N

Network Filter. A system to selectively accept or reject data received from the network. [DIS]

Network Node. A specific network address. **See:** node. **Contrast with:** processing node. [DIS]

Node. A general term denoting either a switching element in a network or a host computer attached to a network. **See:** processing node; network node. [IEEE 1278.1, IEEE 1278.2]

O

Operational Environment. A composite of the conditions, circumstances, and influences which affect the employment of military (or other) forces and the decisions of the unit commander or person in charge. [DIS]

P

Platform. A generic term used to describe a level of representation equating to vehicles, aircraft, missiles, ships, fixed sites, etc., in the hierarchy of representation possibilities. Other representation levels include units (made up of platforms) and components or modules (which make up platforms.) [DIS]

Protocol Data Unit (PDU). A DIS data message that is passed on a network between simulation applications according to a defined protocol. [IEEE 1278.1]

R

Real Time. In modeling and simulation, simulated time advances at the same rate as actual time; for example, running the simulation for one second results in the model advancing time by one second. **Contrast with:** fast time, slow time. [DIS]

Resolution. (1) The degree to which near equal results values can be discriminated. (2) The measure of the ability to delineate picture detail. [DIS]

S

Scenario. (1) Description of an exercise (initial conditions). It is part of the session database which configures the units and platforms and places them in specific locations with specific missions. (2) An initial set of conditions and time line of significant events imposed on trainees or systems to achieve exercise objectives. **See:** field exercise. [DIS, IEEE 1278.3]

SIMNET (Simulator Networking). The prototype distributed simulation upon which DIS was based. [DIS]

Simulate. To represent a system by a model that behaves or operates like the system. **See also:** emulate. [DIS]

Simulated Time. Time as represented within a simulation. **Syn:** virtual time. **See also:** fast time; real time; slow time. [DIS]

Simulation. (l) A model that behaves or operates like a given system when provided a set of controlled inputs. **Syn:** simulation model. **See also:** emulation. (2) The process of developing or using a model as in (1). (3) An implementation of a special kind of model that represents at least some key internal elements of a system and describes how those elements interact over time. [DIS]

Simulation Environment. (1) Consists of the natural physical environment surrounding the simulation entities including land, oceans, atmosphere, near-space, and cultural information. (2) All the conditions, circumstances, and influences surrounding and affecting simulation entities including those stated in (1). [DIS]

Simulation Exercise. An exercise that consists of one or more interacting simulation applications. Simulations participating in the same simulation exercise share a common identifying number called the exercise identifier. These simulations also utilize correlated representations of the synthetic environment in which they operate. **See:** live simulation. [IEEE 1278.1, IEEE 1278.2]

Simulation Fidelity. Refers to the degree of similarity between the simulated situation and the operational situation. [IEEE 1278.3]

Simulation Time. (1) A simulation's internal representation of time. Simulation time may accumulate faster, slower, or at the same pace as real time. (2) The reference time (e.g., universal coordinated time) within a simulation exercise. This time is established ahead of time by the simulation management function and is common to all participants in a particular exercise. [DIS, IEEE 1278.1]

Simulator. (1) A device, computer program, or system that performs simulation. (2) For training, a device which duplicates the essential features of a task situation and provides for direct practice. (3) For distributed interactive simulation (DIS), a physical model or simulation of a weapons system, set of weapon systems, or piece of equipment which represents some major aspects of the equipment's operation. [DIS]

Site. (1) An actual physical location at a specific geographic area, e.g., the Fort Knox Close Combat Test Bed (CCTB). (2) A node on the network used for distributed simulation such as the Defense Simulation Internet (DSI) long haul network. (3) A level of configuration authority within a DIS exercise. [DIS]

V

Validation. See: data validation, distributed simulation validation, face validation, model/simulation validation. [DIS]

Verification. See: data verification, distributed simulation verification, model/simulation verification

Verification and Validation (V&V) Proponent. The agency responsible for ensuring V&V is performed on a specific model or simulation. [DIS]

Vignette. A self-contained portion of a scenario. [DIS]

Virtual Battlespace. The illusion resulting from simulating the actual battlespace. [DIS]

W

War Game. A simulation game in which participants seek to achieve a specified military objective given pre-established resources and constraints; for example, a simulation in which participants make battlefield decisions and a computer determines the results of those decisions. **See also:** management game. **Syn:** constructive simulation; higher order model (HOM). [DIS]

Wide Area Network (WAN). A communications network of devices which are separated by substantial geographical distance. **Syn:** long haul network. [IEEE 1278.3]

APPENDIX D -- List of Acronyms

4 ID	4th Infantry Division, Fort Hood, Texas
ADA	air defense artillery
ADS	advanced distributed simulation
AFATDS	Advanced Field Artillery Tactical Data System
AFB	Air Force base
ALQ-131	a mature self-protection jammer system; an electronic countermeasures system with reprogrammable processor developed by Georgia Technical Research Institute
AM	amplitude modulation
ANIU	air network interface unit
ARIES	Advanced Radar Imaging Emulation System
ARPA	Advanced Research Projects Agency
ASAS	All Source Analysis System
ATACMS	Army Tactical Missile System
A-tracker	automatic tracker
ATWS	Advanced Technology Work Station
Bde	brigade
Bn	battalion
C4I	command, control, communications, computers and intelligence
C4ISR	command, control, communications, computers, intelligence, surveillance and reconnaissance
CAMPS	Compartmented All Source Analysis System (ASAS) Message Processing System
CBS	corps battlefield simulation
CDP	central data processor
CEP	circular error probability
CGS	common ground station
Co	company
COI	critical operational issue
COT&E	contingency operations test and evaluation
CPU	central processing unit
D&SA BL	Depth and Simultaneous Attack Battle Lab
DCT	digital communications terminal
DDSA	deputy director, system assessment
DIS	distributed interactive simulation
DMAP	data management and analysis plan
DoD	Department of Defense
DT&E	developmental test and evaluation
ECCM	electronic counter-countermeasure
ESPDU	entity state protocol data unit
ETE	End-to-End Test
EW	electronic warfare
FDC	fire direction center

FI	functionality and integration
FM	frequency modulation
FTI	fixed target indicator
FTP	file transfer protocol
GHQ	general headquarters
GPS	global positioning system
GSM	ground station module
GSMR	Ground Station Module Replicator, Fort Huachuca, Arizona
HF	high frequency
HLA	high level architecture
hrs	hours
ICD	interface control document
ID	infantry division; identification
IEEE	Institute of Electrical and Electronics Engineers
IPT	integrated product team
JADS	Joint Advanced Distributed Simulation, Albuquerque, New Mexico
Janus	interactive, computer-based simulation of combat operations
Joint STARS	Joint Surveillance Target Attack Radar System
JPO	joint program office
JT&E	joint test and evaluation
JTF	joint test force
km	kilometers
LAN	local area network
LFP	Live Fly Phase
LGSM	light ground station module
LSP	Linked Simulators Phase
M&IS	management and integration software
M&S	modeling and simulation
MB	megabyte
Mbps	megabits per second
MI	military intelligence
mm	millimeter
MOE	measure of effectiveness
MOP	measure of performance
MOT&E	multiservice operational test and evaluation
ms	millisecond
MTI	moving target indicator
N&E	network and engineering
NC	network coordinator
NETVisualizer™	software that displays real-time bandwidth use in a rolling bar graph format for quick visual reference
NIU	network interface unit
NTP	network time protocol
O&C	operations and control
OSD	Office of the Secretary of Defense

OT	operational test
OT&E	operational test and evaluation
OWS	operator workstation
PDU	protocol data unit
PM	program manager
POC	point of contact
PTP	program test plan
PVD	plan view display
RPSI	radar processor simulator and integrator
RSR	radar service request
RWS	remote workstation
SAR	synthetic aperture radar
SCDL	surveillance control data link
SE	synthetic environment
sec	second
SGI	Silicon Graphics, Inc.
SIT	System Integration Test
SM&C	system management and control
SME	subject matter experts
Spectrum	an instrumentation suite used to measure bandwidth utilization
STARS	surveillance target attack radar system
STRICOM	U.S. Army Simulation, Training, and Instrumentation Command
SUT	system under test
SWA	Southwest Asia
T&E	test and evaluation
T-1	digital carrier used to transmit a formatted digital signal at 1.544 megabits per second
TAC	target analysis cell
TAFSM	Tactical Army Fire Support Model
TCAC	Test Control and Analysis Center, Albuquerque, New Mexico
TEMPEST	special shielding against electromagnetic radiation
TEXCOM	U.S. Army Test and Experimentation Command
TRAC	U.S. Army Training and Doctrine Command (TRADOC) Analysis Center
TRADOC	U.S. Army Training and Doctrine Command
UAV	unmanned aerial vehicle
UDP	user data protocol
UHF	ultra high frequency
V&V	verification and validation
VHF	very high frequency
VSTARS	Virtual Surveillance Target Attack Radar System
VV&A	verification, validation, and accreditation
WAN	wide area network
WSMR	White Sands Missile Range
XPATCHES	E-8C synthetic aperture radar simulation developed by Wright Laboratory, Dayton, Ohio, and Loral Defense Systems, Goodyear, Arizona